NOVEMBER 1958

CEP

CHEMICAL ENGINEERING PROGRESS

CEP reports on what's happening in....

titanium

plastics

corrosion mechanisms

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stainless

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future metals

selection methods

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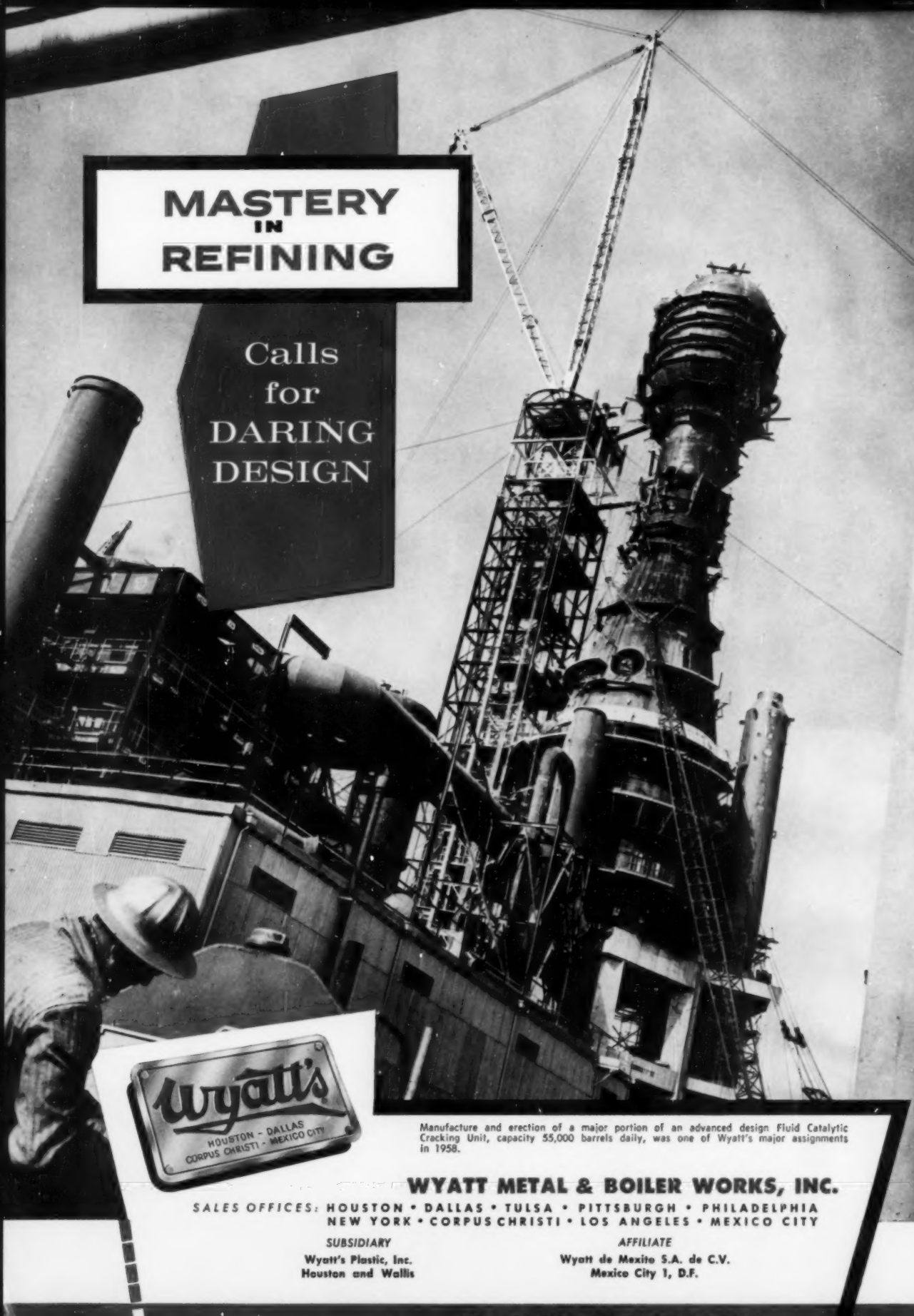

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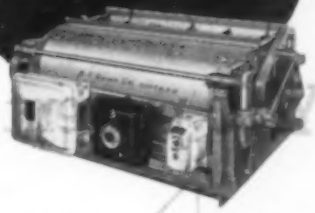
Here's the way to regulate bulk feeding



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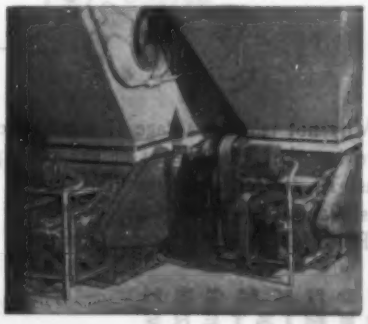

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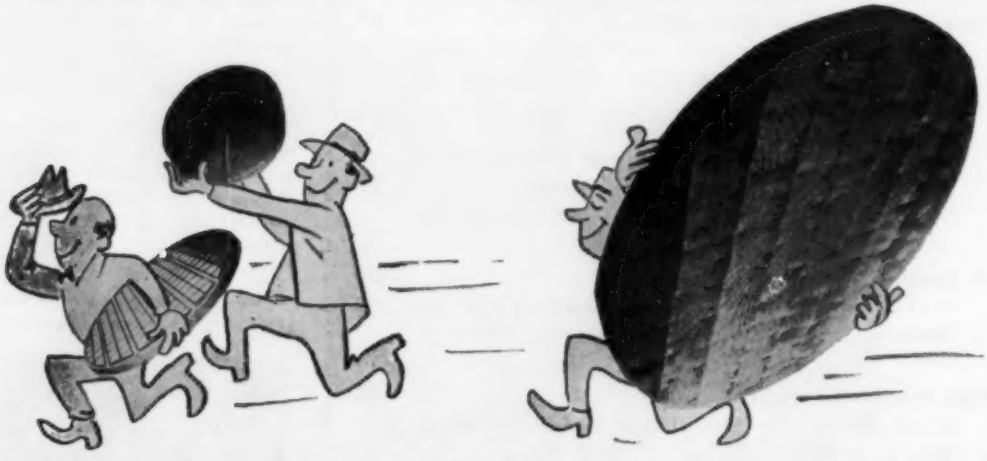

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Cover by Paul Arlt. Photo on cover shows part of Texaco's Port Arthur works.

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Emphasis on Science

PAUL D. FOOTE, *Asst. Secretary of Defense*

The free world military posture is devoted to the deterrence of all forms of aggression. We believe that our own Strategic Air Command is by far the strongest atomic force in the world today and is an essential feature of the total free world military structure. In addition, the U.S. naval task forces are able to move to any place on the high seas and to launch retaliatory atomic attacks. These naval forces will be enhanced in the next several years by the addition of the Polaris submarine missile launching system, a weapon based on the progress being made in the development of solid propellants . . .

Secretary Dulles has pointed out the Soviet goals in economics and in science. He notes the current Soviet boast that they are already supreme in terms of numbers of their scientists and in terms of spectacular scientific accomplishments, and that their rulers say the Soviet Union will become the world's greatest producer of consumer goods. Some details of their claims are questionable, but we should remember that throughout the ages despots have achieved the spectacular. The Pharaohs had their pyramids, the Roman emperors their colosseums, the kings of France their palaces; the rulers of Russia may no doubt produce the equivalent in modern terms.

From the long range point of view, education is the principal factor underlying competence in science and the related dependent economic and military accomplishments. The Soviet Union seems to be using education as an instrument of national policy far more actively than any other nation in the world's history.

Dr. Raymond Ewell of the University of Buffalo, who is presenting a technical paper here at the Golden Jubilee meeting, has recently reported his observations on education in Russia. There is a very high degree of selection of incoming university Freshmen through competitive examinations such that only about one in four applicants is accepted. The applicants have had the benefit of a high quality elementary schooling. In the sciences every child in the first ten years of elementary school takes ten years of mathematics, five years of physics, five years of biology and four years of chemistry.

The emphasis on science and engineering is attained by the annual government allocation of the number of Freshmen to be accepted by the universities and the number in each course. Thus, although the individual student has a freedom of choice in his selection of major study, the openings are limited by the allocation among the various disciplines. The limited openings in the humanities and the preferred status of scientists and engineers in the Soviet Union favor education in science and engineering.

An added feature of Soviet education as found by Ewell shows that 80 to 90 percent of the college students receive full government financial support. Those students who do not get aid are those whose fathers earn enough to pay for the student's education, or those students whose grades drop below an acceptable level. The entire system provides great incentive to the students who work hard because, in effect, their entire future salary level depends on the showing they make in the university.

We are confident that today we have an adequate military and industrial superiority over the Soviets. The important problem facing us is the maintenance of this superiority in the face of the great strides they have made in the past ten years.

The acuteness of the current Soviet challenge has impelled us as seldom before to take stock of our assets and liabilties from the point of view of research and engineering. On review we need not be apologetic about the American achievement in scientific research. For example, by the standards of the international scientific community, we have done exceedingly well during the half century of existence of the A.I.Ch.E. Forty-eight Americans have been honored by Nobel prizes in physics, chemistry, medicine and physiology, as compared with one Russian who shared the chemistry award with a British scholar in 1956.

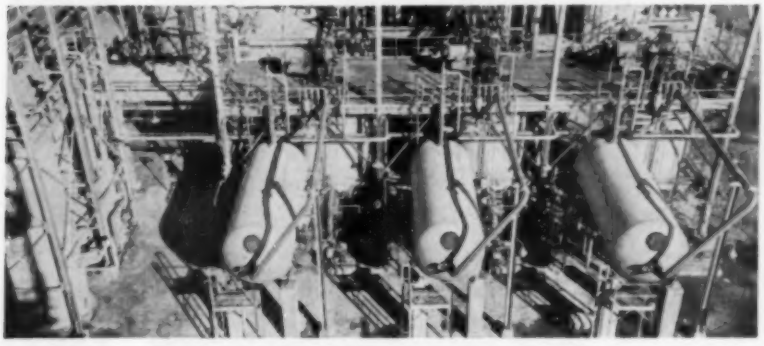
But we have, by a process of self-examination, become concerned about our educational system. Here it is easier to define the nature of some of the more conspicuous deficiencies than to recommend specific courses of action. Certainly we have become painfully aware of the inadequacy of the available scientific preparation in the bulk of the nation's high schools. Some of these deficiencies extend into the colleges and universities where there is a lack of funds to acquire the type of equipment without which neither up-to-date training nor research are possible. Also there are critical salary and prestige factors underlying these deficiencies. Here is an area I commend to you for further action, to each individual as a citizen or as an alumnus; to each industrial and government executive for organizational effort; and to each educator to provide the guidance.

We are also becoming more aware of a number of problems in the management of research and development. In government, and in our corporations, we must give more intensive thought to the planning, the administration and the means for control of programs in the technological fields. This broad area has many facets ranging all the way from gathering statistics and analytical assessment to problems of selection among projects and achieving the optimum balance between support of basic research, applied research and development.

The Year of the Sputniks has brought considerable public criticism on the Department of Defense in this area, and indeed some of the recommendations of the President for reorganization of the Defense Department are intended to strengthen and enhance the management of research and engineering.

In the broad sense, some of these management problems have ramifications far beyond the Defense Department. We in science and engineering are particularly aware that new knowledge is essential to future progress and that a strong military and a strong industrial technology must rest on a base of fundamental science. However, in spite of this realization, I feel that we have not done enough from the management standpoint to provide for the support of basic scientific work. In the Defense Department we have, in the past year, strengthened our policy with respect to basic research and have substantially increased its level of support. This increase amounts to about 30 percent more than was originally planned for the current year. The increase will be continued next year and, we hope, in the succeeding years for budgets not yet prepared. It is important that industry, too, increase its support of basic scientific research both in its own great industrial laboratories and by grants to non-profit institutions.

PFAUDLER CORROSIONEERING NEWS



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The Pfaudlertron is completely electronic. There are no mechanical vibrators or relays.

This device is completely safe. Cannot puncture sound glass. No danger of dielectric breakdown of glass.

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This 1959 issue gives all the more pertinent facts about our complete line of equipment and services, all compacted into twelve pages.

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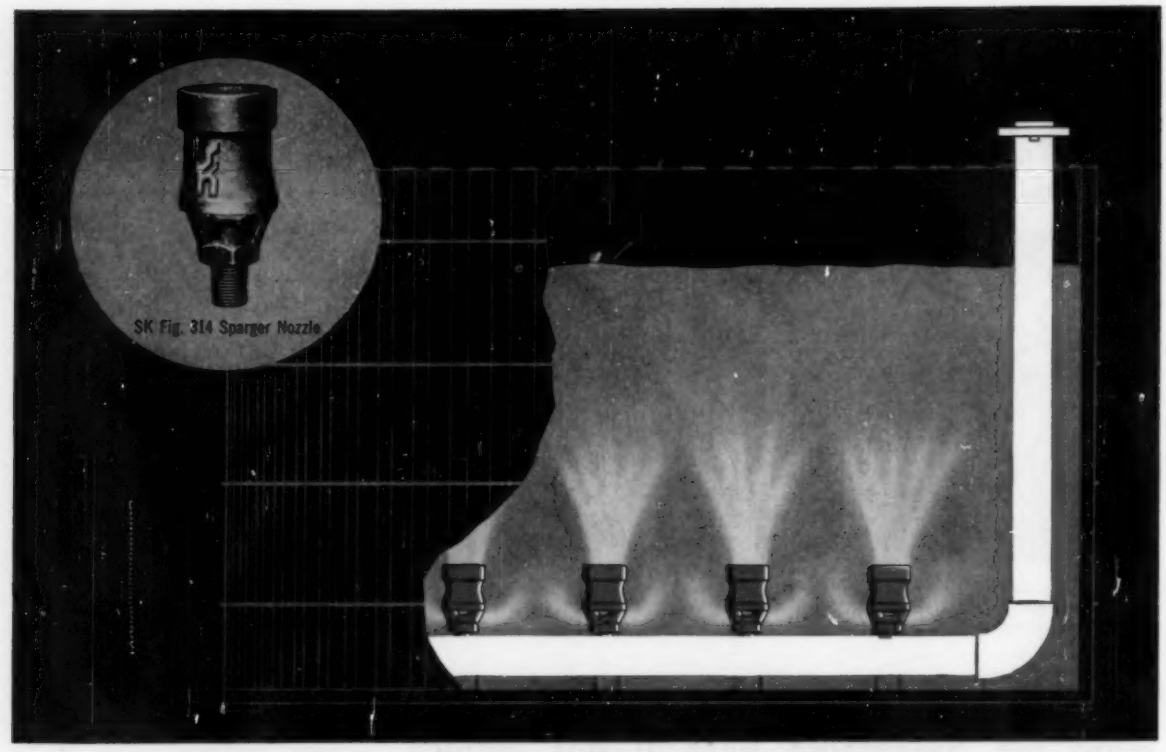
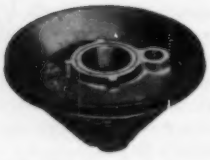


HOW TO HEAT AND AGITATE LIQUIDS IN TANKS

efficiently, economically, and with less noise



SK Fig. 301 Noiseless Heater for Tank Heating

SK Fig. 315 Circulating Heater for Tank Heating

SK Fig. 320 Continuous Heater for Pipe-Line Heating

SK Fig. 327 Slurry Heater for Pipe-Line Heating

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Several other types of SK Steam Jet Heaters—for both tank and pipe-line heating—are shown at left. Complete details on all types are contained in Bulletin 3A which is available on request.

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BISPHENOL "A" Leading chemical companies use S-W pneumatic systems for unloading bisphenol flakes from railroad cars. Installations usually include transfer systems to take material from storage to inplant use.

BOTTLES Soft drink bottles and medicinal bottles are reduced in S-W Single Roll Crushers. This is desired where the beverage bottles are chipped or otherwise damaged; and where bottles used for blood, pharmaceuticals or medicines must be destroyed.

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BULK TRUCK Sprout-Waldron pioneered in the development of bulk handling units, with built-in pneumatic systems which make it possible to load and unload dry, granular materials without back breaking labor, contamination, dusting or waste. Sprout-Waldron bulk trucks have handled materials ranging from peanut shells to cement spanning densifications from 10 to 95 lbs./cu. ft. Chassis sizes range from 12 to 36 feet.

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marginal notes

HIGHER OXO ALCOHOLS. Lewis F. Hatch, Technical Consultant, Enjay Laboratories. John Wiley and Sons, Inc., New York, 1957.
x + 120 pp. 29 figures 15.5 x 23.5 cm. $4.50.

Reviewed by Kenneth A. Kobe, Department of Chemical Engineering, University of Texas.

Professor Hatch, an organic chemist who teaches a course in Petrochemicals at the University of Texas, spent a summer with Enjay reviewing patents and other literature on the oxo process. This book summarizes the survey on this one phase of the oxo process and products.

The initial chapter discusses the oxo process, flowsheet, catalysts, mechanisms and side reactions. The second chapter divided the oxo aldehydes and alcohols into those of lower molecular weight, and isooctyl and above, which are the subject of the survey. The chapter gives physical properties, isomer distribution and reactions of the compounds. Subsequent chapters deal with applications as plasticizers, agricultural applications, detergents, and lubricant applications. There are 409 references, largely to patents.

Here is a patent survey, well documented and well written.

NICKEL AND ITS ALLOYS, J. G. Thompson, National Bureau of Standards Circular 592 (February 5, 1958), 87 pp., 60¢. Order from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

A review of available literature through 1956, as well as some 1957 references and unpublished information. Covers occurence of minerals, uses and properties of high-purity and commercial forms of nickel, and properties and industrial applications of its important ferrous and nonferrous alloys. About 800 supplementary references.

MONTHLY INDEX OF RUSSIAN ACCESSIONS, Government Printing Office, $12 per year. EAST EUROPEAN ACCESSIONS INDEX, Government Printing Office, $10 per year.

Each index gives in English a monthly account of new material in a variety of subject fields as received from the USSR and East Europe by the Library of Congress and other American research libraries. Elaborate subject guides in English permit a researcher who has no command of Russian or East European languages to

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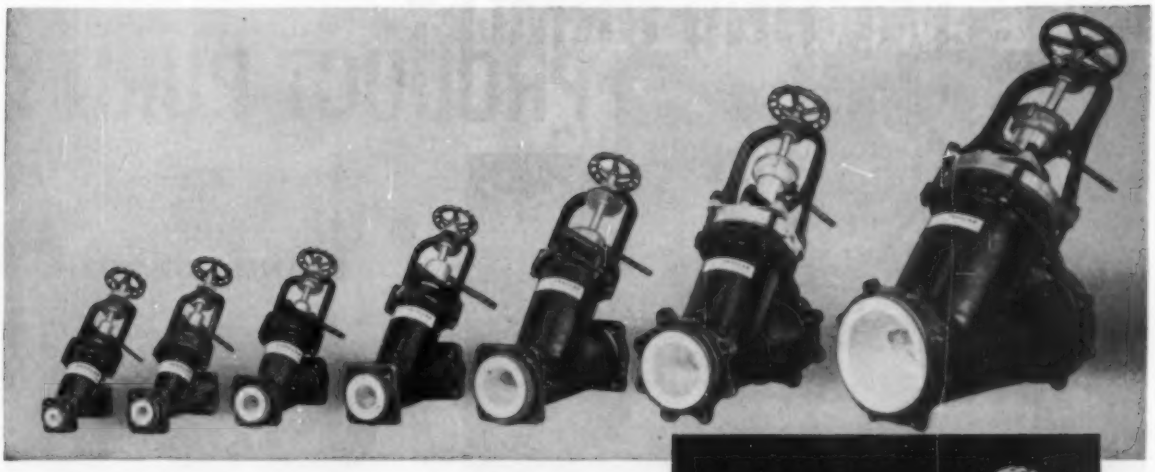

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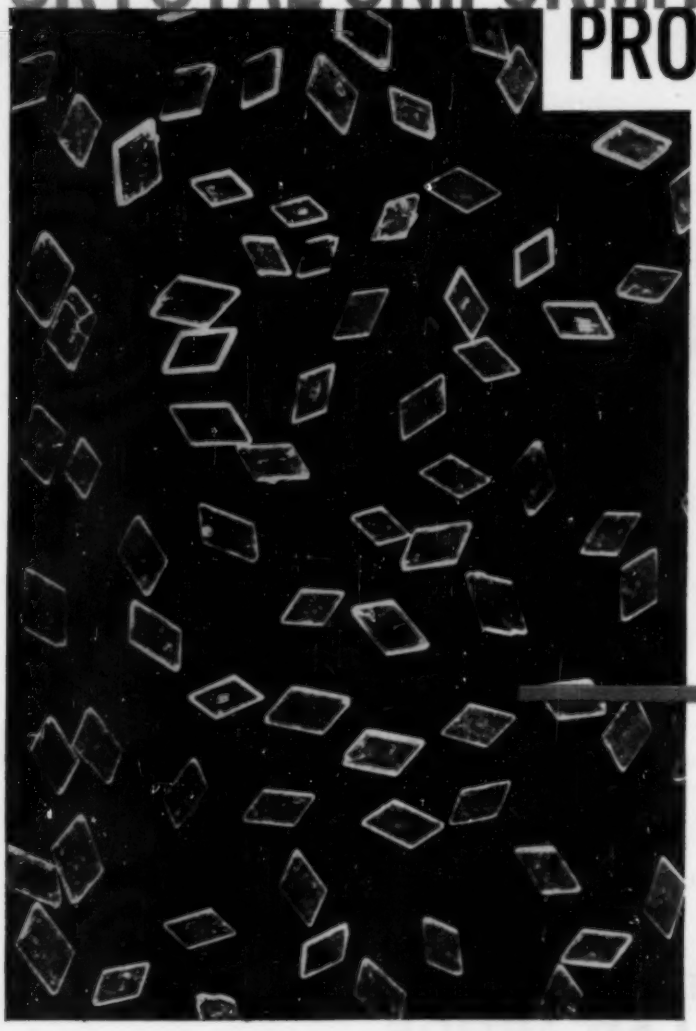

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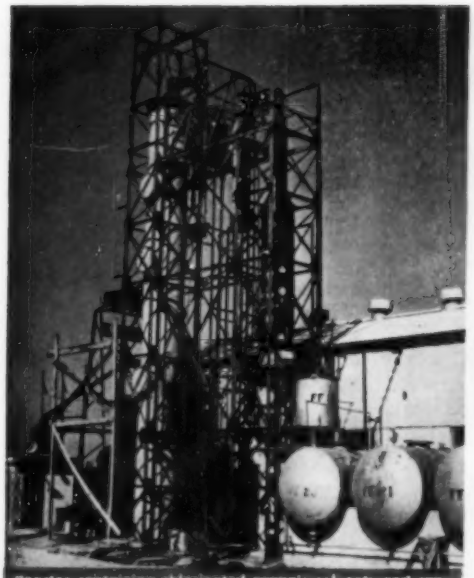

Reactor containing chlorinated organic solvents and concentrated HCl at 280°F. Duro-Line membrane protected with brick jointed with Lecite.

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COATINGS

Duro-Prene — Neoprene* Base
Nitro-Dur — Epoxy Base
Duro-Kote — Polyvinyl Chloride Base
Kemitite — Asphalt Base
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*Trade name — E. I. du Pont de Nemours †Trade name — Minnesota Mining & Mfg. Co.

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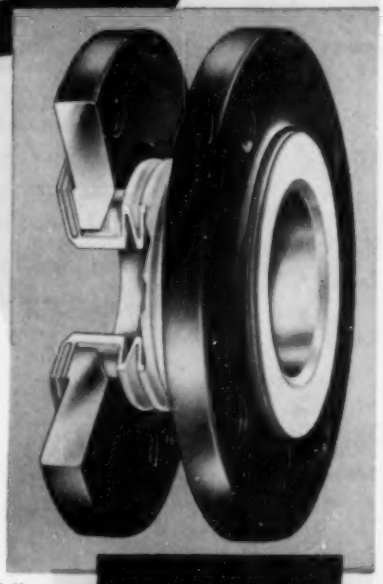
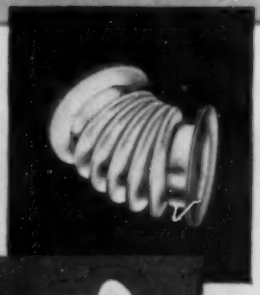
*"John Crane" fabricated from DuPont Teflon



When it is a question of chemical piping—where you need anti-corrosive protection, plus long life—Chemlon Connectors best meet the need. They are fabricated from the most chemically resistant material available, DuPont Teflon. The most destructive acids, corrosives and solvents have no deteriorating affect*

Other important advantages are their long service-life, extreme flexing ability and wide temperature range from —65°F. to +350°F.

Chemlon flexible pipe connectors offer a definite plus value construction-wise. 1) They are made from Teflon specially fabricated for high and uniform density. 2) An exclusive manufacturing method assures uniform wall thickness throughout the convoluted area. 3) They are formed at full free length to reduce residual and working strain to an absolute minimum.



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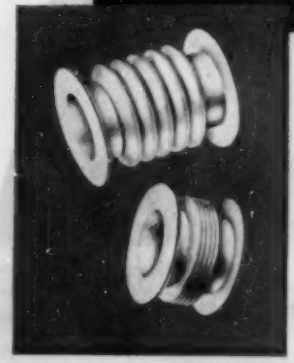
—severest vibration and misalignment conditions, such as pump to agitator or mixer to tank, will cause little deterioration or fatigue. Also, the Chemlon Flexible Pipe Connector serves as an acoustical as well as a mechanical dampener.

Expansion and Contraction

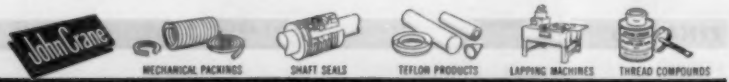
—continuous flexing over a wide range of temperature conditions has little affect on Chemlon Flexible Pipe Connectors.



Chemlon Flexible Pipe Connectors handle pressures to 75 psi., dependent on size. They can be supplied to fit any pipe size from ¼" to 12" and are available with companion flanges conforming to American Standard Class 125 Cast-Iron Pipe Flange specifications.

Request full information. Crane Packing Co., 6443 Oakton St., Morton Grove, Ill., (Chicago Suburb). *In Canada: Crane Packing Co., Ltd., Hamilton, Ont.*

**Except fluorine and molten alkali metals.*



CRANE PACKING COMPANY

from page 10

identify easily the material important to him.

The indexes are of particular value to the scientist. For example, 54% of the books and periodicals reported in Volume 9 (April 1956–March 1957) of the Monthly Index of Russian Accessions were in the field of science and technology.

For further details, call Information and Publications Office, Library of Congress, STerling 3-0400, Ext. 605, Washington, D. C.

DISSERTATION ABSTRACTS, Vol. XVII, (1957), 1428 pp. (monthly) University Microfilms, Ann Arbor, Michigan: ($20.00/yr. U.S.).

Principal subject headings include agriculture; anatomy; astronomy; bacteriology; chemistry; economics, education; engineering; food technology; geology; health sciences; mathematics; mineralogy; philosophy; physics; psychology; and author index.

WATER FOR INDUSTRIAL USE. UNITED NATIONS DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS, Columbia University Press, New York, i+viii and 44 p. (1958) 50 cents.

This pamphlet contains a brief review of problems which arise from the demand for water by industry in competition with older and more traditional claims on water resources. Quantity and quality aspects are taken up water costs analyzed. Statistical tables are a feature of this work.

SELECTION OF MANAGEMENT PERSONNEL, M. J. Dooher and E. Marting, American Management Association, New York, Vol. I & II, 906 pp. (1957).

SUPERVISORY AND EXECUTIVE DEVELOPMENT, A MANUAL FOR ROLE PLAYING, N. R. F. Maier, A. R. Solem, A. A. Maier, John Wiley & Sons, Inc., New York (1957).

Research Management **is a new quarterly magazine, one volume per year,** published jointly by the Industrial Research Institute and Interscience Publishers, Inc. C. M. Burrill, affiliated with RCA Laboratories, Princeton, New Jersey, is editor. In the spring 1958 Vol. I No. 1, Mr. Burrill states that "there has been no one place to turn for the latest ideas regarding research management discussed from the research administrator's point of view." Thus, the need, he implies, for *Research Management.*

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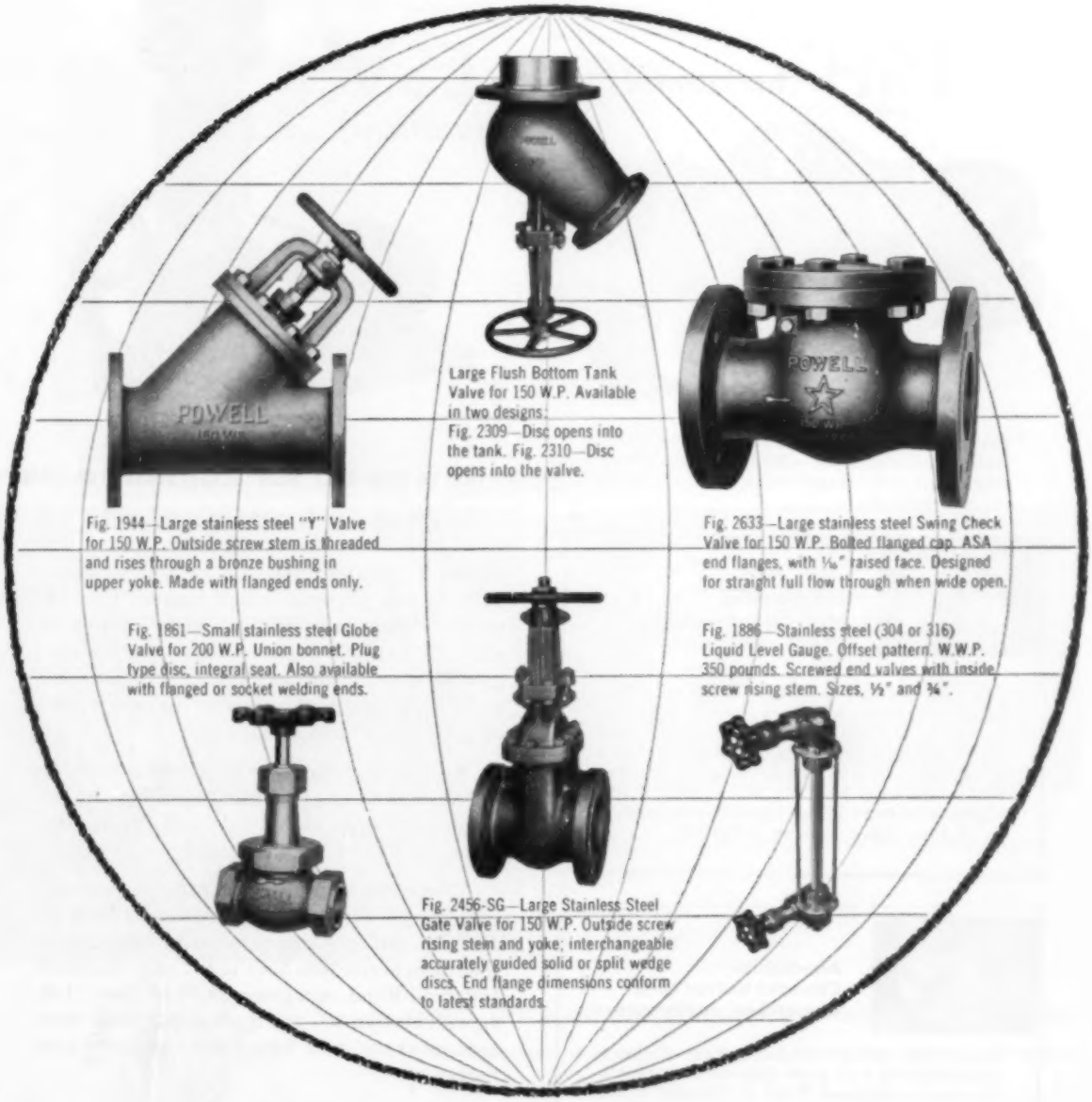
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Large Flush Bottom Tank Valve for 150 W.P. Available in two designs: Fig. 2309—Disc opens into the tank. Fig. 2310—Disc opens into the valve.
Fig. 1944—Large stainless steel "Y" Valve for 150 W.P. Outside screw stem is threaded and rises through a bronze bushing in upper yoke. Made with flanged ends only.
Fig. 2633—Large stainless steel Swing Check Valve for 150 W.P. Bolted flanged cap. ASA end flanges, with 1/16" raised face. Designed for straight full flow through when wide open.
Fig. 1861—Small stainless steel Globe Valve for 200 W.P. Union bonnet. Plug type disc, integral seat. Also available with flanged or socket welding ends.
Fig. 1886—Stainless steel (304 or 316) Liquid Level Gauge. Offset pattern. W.W.P. 350 pounds. Screwed end valves with inside screw rising stem. Sizes, ½" and ¾".
Fig. 2456-SG—Large Stainless Steel Gate Valve for 150 W.P. Outside screw rising stem and yoke; interchangeable accurately guided solid or split wedge discs. End flange dimensions conform to latest standards.

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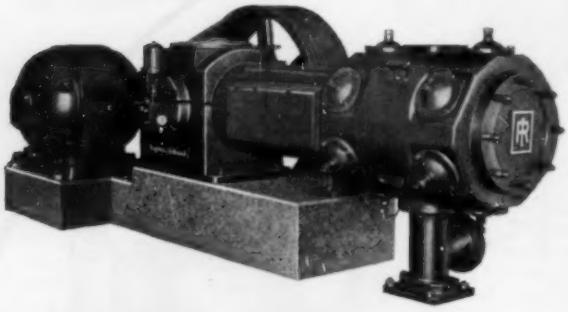
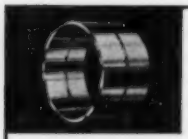


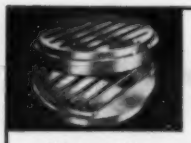
ESV* (vertical)

*The same compressor in either horizontal or vertical arrangement – 20 to 150 hp sizes, single-and multi-stage, pressures up to 5000 psi and vacuums.



Full-floating aluminum bearings never need adjustment

The full-floating bearings "roll with the punch," taking each thrust on a different portion of the shell. They are foolproof, and never require fitting or adjustment. Main and crankpin bearings are made of I-R's special aluminum bearing alloy, which has higher load capacity and better heat conductivity than other bearing materials.



Air-cushioned Channel Valves give unmatched performance

Known the world over for lasting efficiency, dependability and quiet operation, Ingersoll-Rand air-cushioned Type A Channel Valves are entirely different in design and principle from any other valves in use. Type A Channel Valves were developed especially for modern compressor speeds, and feature a separate stainless-steel seat plate which can be reversed or replaced for new life.

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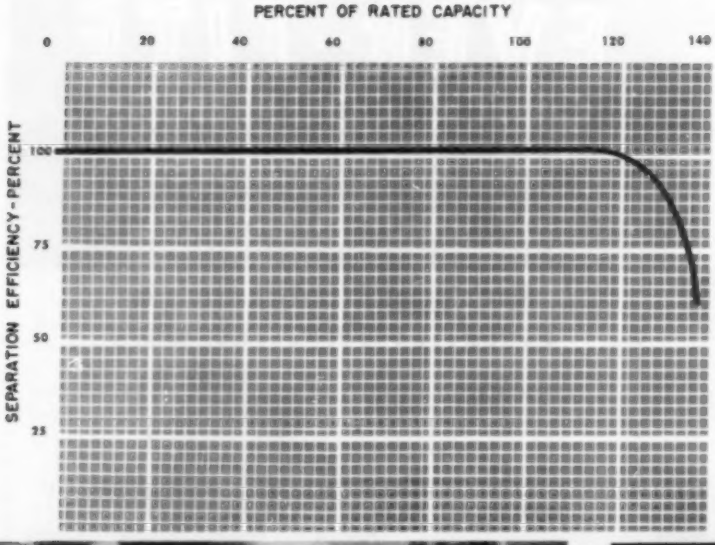
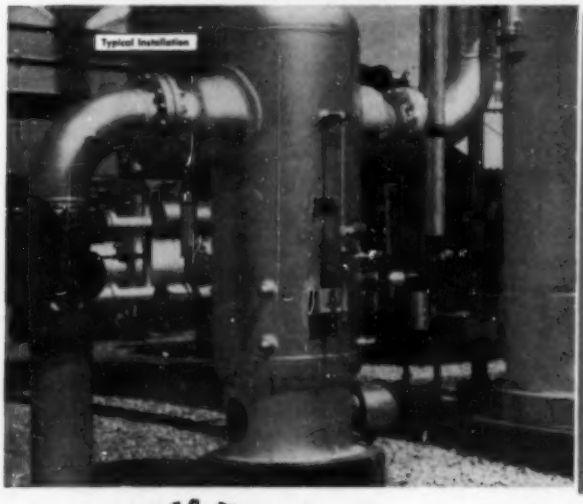
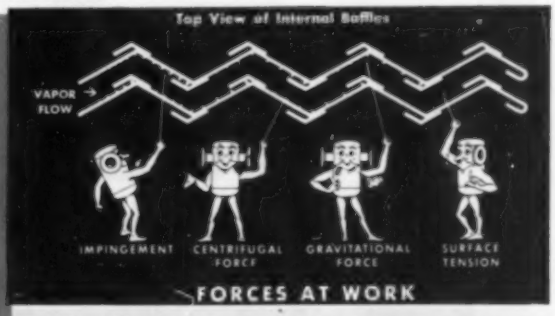
FLAT EFFICIENCY CURVE with PEERLESS Separators...



with Peerless Separators you can remove entrained liquids from process vapor lines and maintain a high efficiency over the entire range of flow.





The above illustration shows a top view looking down at two of the many internal separator baffles. Entrained liquid droplets are caught in the pockets and drained down out of the gas flow . . . thereby completely stripping the gas before it leaves the mist extractor.

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SCOPE

New Court Action on Trade Secret Rights

Chemetron Corp. has charged in a complaint filed in Wilmington, Del., that a company formed by a group of its former employees is "threatening" to violate a previous agreement by offering to divulge Chemetron's catalyst trade secrets and confidential information to European manufacturers. Defendant in the action is Catalysts and Chemicals, Inc., of Louisville, Ky.

The new action is a sequel to a previous suit, settled out of court last March—the case of National Cylinder Gas Co. (now Chemetron) versus nine individual engineers, all associated with Catalysts and Chemicals. In this previous suit, National Cylinder Gas charged, in effect, that the nine individual engineers were planning to use, illegally, technical information acquired when they were in the employ of National Cylinder Gas. These charges were later withdrawn.

The out-of-court settlement in this previous case did not, unfortunately, provide a clear-cut precedent. According to the terms of the agreement, Catalysts and Chemicals was granted a non-exclusive license to use the alleged trade secrets and confidential information involved. In return, Catalysts and Chemicals is reported to have agreed to pay a minimum of $500,000 over the next seven years, the schedule of payments to be calculated as a percentage of catalyst sales. The fact that a large sum of money was involved in the out-of-court settlement, seemed to indicate that National Cylinder Gas's case carried legal weight. On the other hand, in a statement to *CEP*, R. E. Reitmeier, president of Catalysts and Chemicals and one of the individual defendents in the case, said that there is no basis for this presumption. The financial settlement was made, said Reitmeier, purely for business reasons—to expedite the catalyst sales of the new company (Catalysts and Chemicals) and to avoid long-drawn-out legal proceedings and probable large legal costs.

Net result so far, in this as in other recent cases in this general area—for example, the case of Monsanto Chemical versus Charles M. Miller and F. C. Torkelson Co.—is that no clear-cut court decision is yet on record to guide the individual engineer (or the company) in the matter of their respective rights to ownership of know-how acquired by an employee in the performance of his engineering duties.

It is encouraging that several of the great American technical societies are beginning to take a very active interest in all phases of the question. In the much publicized Spevack case, for example, where an individual was trying legally to prevent AEC from releasing certain information before he had time to file patent applications, both A.I.Ch.E. and the American Chemical Society filed briefs as friends of the court.

Helium supply called critical, conservation effort pushed

Meeting in closed session at Amarillo, Texas, in October, 150 government technologists considered ways and means to conserve our national supply of industrially and militarily vital helium. Held under the sponsorship of the Bureau of Mines, the meeting was at the instigation of AEC's George Kirkley, on whose shoulders falls the task of doling out the scarce element to industry for defense projects. U. S. helium demand, after rising to a war-time peak of 140 million cu. ft. in 1944, dropped back to 60 million in 1946; started to rise again in 1950. Estimated demand for the current fiscal year is 450 million cu. ft.—production capacity, 345 million cu. ft. Largest consumers are the Navy, Air Force and AEC; about 25% goes to industry, of which about 50% is used on government projects. The 85th Congress made available funds for the construction of a $12 million facility for helium extraction from natural gas. Not passed, however, was a $525 million long-range program proposed by a "working group" drawn from interested government agencies under O. Hatfield Chilson, Undersecretary of the Interior. Favorable action is anticipated during the next session of Congress. In the meantime, the October Symposium at Amarillo came up with a set of suggestions for control, handling, and use of helium. Users are urged to check empty cylinders carefully, to set up an effective leak detection program, to use regulators for throttling instead of shut-off valves, to use low pressure and low flow rates when purging systems. —*J. L. Gillman, Jr.*

Aneth oil wells ordered closed to stop gas loss

Following determination by the Geological Survey that about 64 million cu. ft. of natural gas was being lost daily from 327 wells in the Aneth, Utah, field, the Interior Department has ordered suspension of operations until a pipe line can be constructed to collect and save the natural gas. It is understood that a crash program is already underway.

SCOPE

The 85th Congress and the Engineer

Significant to engineers of all persuasions should be the fact that the new Director of Defense Research and Engineering, whose post replaces that of the former Assistant Secretary of Defense for Research and Engineering, is considered a personage of such key importance that the House Committee on Armed Services has provided that he be a member of the Armed Forces Policy Council.

This provision of the Defense Reorganization Act, just passed by the 85th Congress, seems to reflect a growing comprehension and appreciation of the role of the engineer in national affairs, as opposed to that of the purely theoretical scientist who, up to now, has perhaps received a disproportionate share of the kudos—and, at times, the opprobrium.

The trend toward reorganization of engineering and scientific matters in the Executive Branch is further underlined by the formation of a standing twenty-five man House Committee on Science and Astronautics. This Committee will supervise not only the congressional affairs of the newly-formed National Aeronautics and Space Administration, but also the National Science Foundation and such other general matters as science scholarships, research and development, etc.

The National Defense Education Act of 1958 was passed with but one serious rebuff to the Administration—the omission of a requested scholarship program. The Act does, however, make an initial appropriation of $295 million for loans to college students over the next three years. Special consideration will go to students whose background indicates superior capacity in science, mathematics, engineering, or modern languages. Another $280 million will go to strengthen science, mathematics, and modern language instruction in elementary and secondary schools.

The system of national defense fellowships set up by the Act, while laudable in intent, is a question mark. While stipends and dependency allowances seem rather liberal, it remains to be seen whether they can compete effectively with industrial job opportunities for the best engineering graduates.

Title VIII of the Education Act promises to have far-reaching effects on the question of the training of engineering technicians. In effect an amendment to the Vocational Act of 1946, it provides $60 million—to be matched dollar for dollar by the states—for area vocational education programs. In some engineering circles, it is considered that this program will allow those who run vocational education in the various states to move into the area of training engineering technicians, and that the results will not be necessarily good in all cases.

Under Title IX of the Act, the National Science Foundation has been directed to establish a Science Information Service to expedite indexing, abstracting, and translation, and to develop new methods for making scientific information available. EJC has offered to the National Science Foundation its assistance in the setting up of the Science Information Council, which will be an advisory group to the Science Information Service.

More workable fiscal arrangements in the domain of basic research may well result from the passage of Bill S. 4039, signed by the President in September. Under the new dispensation, heads of Federal agencies are authorized to make outright grants to nonprofit educational institutions for basic research. Formerly, such Federal aid was on a strictly contractual basis.

Washington Notes

AEC is said to be studying direct production of electricity from encapsulated isotopes. Initial studies are aimed at developing heat elements resistant to high temperature shock, corrosion and erosion, and other deterioration over long periods of time. . . . *John Dunning and E. T. Booth of Columbia University*, Alfred O. Nier of the University of Minnesota, and Aristid V. Grosse of Temple University are said to have filed with the U. S. Patent Compensation Board a claim that the gaseous diffusion process for separating U-235 was developed with private funds; the plaintiffs are reported to be asking a cash award of 3% of the value of all U. S.-produced enriched uranium or 6% of the capital value of all U-235 plants. . . . *Use of controlled nuclear explosions in production of oil* from shale is reported to have been the subject of an October 15 meeting of AEC representatives from the San Francisco Operations Office and the Radiation Lab at Livermore, Calif. with representatives of the Bureau of Mines. . . . *About 90.6 million kilowatts of potential hydroelectric power* capacity is still available for future development in the United States, says a recent report of the Federal Power Commission. . . .

—*J. L. Gillman, Jr.*

Employee indifference to politics seen danger to democracy

Corporation employees, who avoid political activity for business reasons are endangering American democracy, according to Andrew Hacker, professor at Cornell.

SCOPE

Iron Curtain Countries Claimed Dumping Basic Chemicals

Cut-rate competition from behind the Iron Curtain is both a current and a long-range problem for domestic marketers of two important basic chemicals, benzene and naphthalene, warned O. V. Tracy, V.P. and director of Esso Standard Oil, speaking before the recent annual meeting of the American Coke and Coal Chemicals Institute at White Sulphur Springs, W. Va.

Foreign naphthalene is consistently offered here at below U.S. quotations, and imported cargos contributed to a 5 cent per gallon drop in the benzene market last July, said Tracy, adding that most of this foreign naphthalene and benzene has come from behind the Iron Curtain.

In 1955, 29 million gallons of benzene were imported into the United States. It is estimated that imports will be nearly twice as high from now through 1965. This volume will comprise from 11 to 12% of domestic consumption, compared to 9% in 1955. Although European demand for both benzene and naphthalene is expected to increase, said Tracy, it is unlikely that this will lessen the volume flowing into world markets. The Soviet satellite countries, and also West Germany, will soon be able to increase their production greatly as a result of enlarged coking operations and improved naphthalene recovery.

Casting a somewhat jaundiced eye on the domestic prospects for benzene consumption, Tracy went on to predict that total U.S. production will reach 400 million gallons by 1960, and 475 million gallons by 1965. The petroleum industry now supplies about 30% of domestic production, and by 1965 will be producing 43%, he estimates. By-product coke operations in the U.S. supply more than half of our domestic benzene, and a much larger share of our naphthalene. With today's requirement total of 335 million gallons of benzene, it will evidently be five years or more before potential domestic production could be marketed—even if imports should dry up entirely.

Tracy continued with a look at the prospects for the big-consumption uses for benzene. Styrene, he thinks, although its position is being preempted in some uses by polyethylene and other plastics, has considerable growth potential, especially as a component of GRS-type synthetic rubber. However, as synthetic rubber plants come into operation in Europe, the U.S.-produced product may lose much of its export market. Other major outlets for benzene—phenol, nylon, detergents, and insecticides—show more vitality, opines Tracy, although the consumption curve for benzene in phenol can be expected to flatten out somewhat.

U. of Michigan, MIT, lead in ChE degrees

According to the 1957-1958 Chemical Engineering Faculties, now available from A.I.Ch.E. headquarters, New York, total B.S. degrees granted in 1957-58 in chemical engineering totaled 3,083, M.S. degrees 612, and Ph.D. degrees 136. Top five schools in the U.S. ranked as follows:

B.S. Degrees		M.S. Degrees		Ph.D. Degrees	
Purdue	100	M.I.T.	90	U. of Mich.	19
M.I.T.	91	U. of Mich.	61	M.I.T.	11
U. of Mich.	78	Newark Coll. Eng.	23	U. of Ill.	7
Brooklyn Poly.	76	Columbia Univ.	16	U. of Wis.	6
U. of Texas	70	U. of Wis.	16	Cornell Univ.	5

Patent agreements foster competition, says Cyanamid

Answering an FTC price-fixing complaint, American Cyanamid points out that licensing agreements between Cyanamid and Pfizer enabled Pfizer to make and sell tetracycline, made from chlortetracycline which is covered by a Cyanamid patent. Another agreement made it possible for Cyanamid to continue to make and sell tetracycline under a Pfizer patent. Such agreements, claims Cyanamid, far from restricting trade, have made it possible for five companies to "compete vigorously in the sale of tetracycline."

UET names new officers

Andrew Fletcher, president of St. Joseph Lead Co., has been designated as the new president of United Engineering Trustees, Inc. Fletcher succeeds Walter J. Barrett of Bell Telephone (New Jersey) who has held the office since 1955. Other new officers are: Willis F. Thompson and George W. Burpee, vice-presidents; Charles B. Molineaux, treasurer; Walter E. Lobo, assistant treasurer; and Steven W. Marras, secretary and general manager. As of mid-October, pledges toward the new United Engineering Center approached the halfway mark—the grand total stood at $4,384,092. A.I.Ch.E. continued to hold its lead percentage-wise in the Member Gift Campaign, with 33% of its $300,000 quota subscribed.

PROCESS SIMULATION

Where is it used ?

In Research Studies—Process Simulation:

- Bridges the gap between empirical data and theoretical expressions.
- Accelerates the determination of the effect of possible parameter variations.
- Quickly defines missing data required for completion of the study.
- Provides quick and convenient evaluation of theoretical equations.

In Process Design—Process Simulation:

- Permits rapid selection of the best of several design concepts.
- Provides faster optimization of proposed design parameters.
- Assures design on a more fundamental basis.
- Facilitates more accurate scale-up of available pilot-plant data.
- Permits specifications of operating conditions for new designs that are closer to the safe, reasonable limits of the design.
- Applications include distillation columns, absorption beds, continuous reactors, catalytic reactors, heat exchangers, and many others.

In Control Instrumentation—Process Simulation:

- Is especially effective in the accurate representation of instrumentation systems to facilitate integration of control elements.
- Provides special advantages in studying multi-loop and unusual control systems.
- Permits reliable preconstruction specifications and performance requirements for instrumentation planning.
- Considerably reduces cut-and-try engineering.
- Facilitates establishment of pre-trial-run specifications of start-up procedures.

In Optimization of Existing Processes—Process Simulation:

- Permits economical exploration in operating conditions, equipment, and controls without expensive experimentation or production upsets.
- Safely and accurately locates adequate and reasonable safety limits.
- Evaluates proposed changes in process such as side-draws, reflux ratios, piping changes, pump performance, etc., without costly commitments of equipment.

The observations recorded are not guesswork. They represent the results of many hours of experimentation and study acquired by engineering groups of leading companies in the Chemical, Petro-Chemical, and Petroleum fields. These studies have been performed either on their own equipment or on analog computing equipment rented at any of EAI's completely staffed and equipped computation Centers in Princeton, New Jersey; Los Angeles, California; or Brussels, Belgium.

PROCESS SIMULATION

COMES OF AGE

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U.S.I. CHEMICAL NEWS

Nov. ★ A Series for Chemists and Executives of the Solvents and Chemical Consuming Industries ★ 1958

Methods for Making Borane Fuels Now Being Piloted

Operation of a high-energy-fuel pilot plant for the Air Force began recently at AFN, Inc., Henderson, Nevada. The company is owned jointly by American Potash, Food Machinery, and the U.S.I. Division of National Distillers (see U.S.I. Chemical News—February 1958).

This new plant is a process development unit designed, engineered and constructed by AFN under Air Force sponsorship to develop a large-scale production method for alkyl borane high energy fuels, materials of great importance to the nation's missile program.

ATTENTION: Users of Specially Denatured Alcohol

Citric acid may now be added to toilet preparations containing tartar emetic to prevent clouding, according to an industry circular issued by the Alcohol and Tobacco Tax Division.

Since issuing the regulation that tartar emetic or sucrose octa-acetate must be added to bay rum, alcoholado, or alcoholado-type toilet waters made with specially denatured alcohol, the Division has discovered that tartar emetic produces cloudiness in formulations.

The Division recommends the use of one-quarter grain of citric acid per fluid ounce of finished product to eliminate cloudiness. The circular says: "Permittees now holding approved formulas for the manufacture of alcoholado or bay rum containing tartar emetic and who elect to add citric acid . . . need not submit new formulas on Form 1479-A. However, formulas submitted in future for these products in which citric acid is to be used must show such use."

Cetyl Alcohol "Blanket" Lowers Water Evaporation

Researchers have discovered that a one-molecule-thick layer of cetyl alcohol, spread on the surface of water in a reservoir, can reduce evaporation by as much as 65%. A pound of this harmless chemical will cover 10 acres of surface and last about 3 days against the action of wind and dirt. It is calculated that a pound per acre per month provides adequate protection, and that millions of dollars could be saved this way yearly in areas where water is usually in short supply.

Cetyl alcohol acts by spreading over the water surface to seal out air. It must extend to the reservoir banks to be effective. Its self-healing property insures that there will be no uncovered places on the surface for long, should wind or dirt break the coating.

Some practical problems must be solved before usage can become widespread. These include methods of applying and replacing the chemical. One solution being examined involves placing pelletized cetyl alcohol in screens on floats or buoys on the water.

Tests Confirm That Methionine Is Absorbed Through the Skin

Known Healing Properties of Methionine, Plus Proof Of Skin Absorption, Suggest Wide Application in Topically Applied Cosmetics, Toiletries, Medications

It has been established by thorough study that methionine is absorbed by the body when applied to the skin. Radioactive tracer studies made with guinea pigs reveal that administration of methionine by skin has nearly half the efficiency of oral feeding.

Methionine is an essential sulfur amino acid, a precursor of cystine in the skin, hair, nails and other tissues. It has been shown previously that methionine administered orally:

- decreases healing time of surface wounds
- cures some forms of diaper rash
- aids in disappearance of warts
- protects against radiation damage
- helps reduce tumor growth
- overcomes urinary infections

Experience with topical application has revealed that methionine:

- promotes rapid healing of burns and other wounds
- heals varicose leg ulcers
- promotes good skin tone
- has helped in treatment of falling hair

Now that definite experimental data has been compiled on the rate and extent of methionine absorption through the skin, it is felt that its healing properties can be utilized

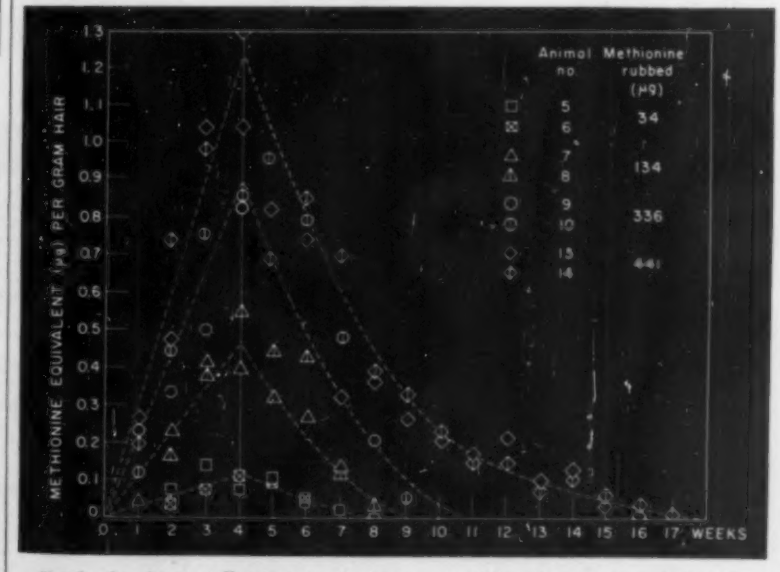
MORE

Esters of ISOSEBACIC® Acid Compare Well with Other Vinyl Plasticizers

Octyl esters of the new U.S.I. ISOSEBACIC acid have been evaluated against accepted vinyl plasticizers in a complete series of tests at the U.S.I. laboratories. The performance results have been coupled with current price information to yield comparisons which should be of interest to makers of vinyl plasticizers.

Here are the conclusions. Octyl isosebacates are less expensive than sebacates and are closely competitive in overall performance. They have an edge over azelates on cost and are about equal in performance. While comparing closely on cost with adipates, they are better on overall performance.

ISOSEBACIC acid is a new synthetic intermediate developed by U.S.I. — a mixture of 2-ethyl suberic, 2, 5-diethyl adipic and sebacic acids. It will soon be available commercially from a new U.S.I. plant at Tuscola, Ill.



Uptake of methionine (S^{35}) in hair of rubbed guinea pigs. (Edwards, L. J.: *Nature*, 173, 1042)

Nov. ★ **U.S.I. CHEMICAL NEWS** ★ 1958

CONTINUED

Methionine

extensively by formulators of cosmetics, toiletries and topically applied medications. Creams and lotions to maintain skin tone, treat burns and sunburn, and hasten the healing of minor cuts, scratches and abrasions are among the possibilities. Incorporation into baby talcs, after-shave lotions and men's hair preparations is also indicated. The possibilities are many.

Test Procedures

Here's how the tests were made. Methionine labeled with a radioactive sulfur (S^{35}) tracer was applied in aqueous solution to a shaved area on the backs of the test guinea pigs by gentle rubbing. The same solution was also injected intramuscularly into a second group of guinea pigs, and fed orally to a third group. Hair from the treated animals was clipped at weekly intervals, washed, and its radioactivity determined. The per cent of absorption by these three methods of application were, respectively, 1%, 3-5%, and 2%, based upon the test results.

The animals subjected to topical application were treated four days a week for four weeks. Their hair showed a steady build-up of radioactivity during this time. When application was stopped, radioactivity declined steadily. The chart on the preceding page shows the curve.

New Surface Treatment for Polyethylene Makes It Receptive to Printing Ink

A new chemical treatment for giving the surface of polyethylene an affinity for printing inks is outlined in British Patent 772,803. Two types of chemical solutions are mentioned:

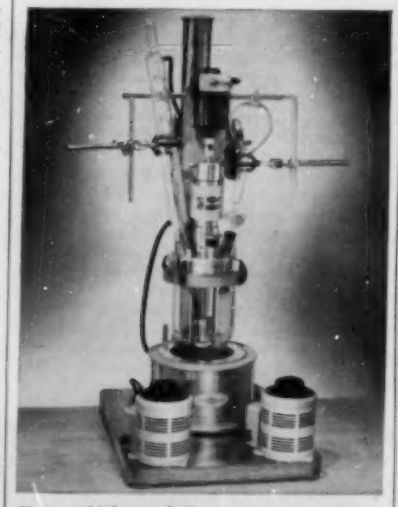
(1) A 4% aqueous solution of a permanganate containing 10-30% by weight of sulfuric acid. A brown permanganate stain results which can be removed with potassium bisulfite without affecting film's receptiveness to ink.

(2) A 30% aqueous solution of a chromate or dichromate containing not more than 30% by weight of sulfuric acid. Both chemical treatments are followed by washing and drying.

New High-Speed Stirrer For Dispersing Sodium

A new unit, designed to apply high-speed stirring to many types of small-scale chemical reactions, has been tested and found satisfactory for dispersing sodium. As part of a research program on preparation and uses of sodium in dispersed form, the U.S.I. laboratories have evaluated the new Chemtor Dispersion Reactor and have found that it compares favorably with other small-scale units suggested in the U.S.I. literature (see the 42-page U.S.I. brochure "Sodium Dispersions" for complete discussions of Cowles Dissolver, Premier Mill Dispersator, Waring Blendor).

The Chemtor Dispersion Reactor, like the others, can be used to increase the surface area of sodium — for faster reactions and higher yields — in Claisen condensations, Wurtz-type reactions, purifications, metallations, preparation of sodium alcholates, preparation of alkyl and aryl sodium, polymerizations and replacement of acidic hydrogen.



Chemtor high-speed dispersion reactor system.

TECHNICAL DEVELOPMENTS

Information about manufacturers of these items may be obtained by writing U.S.I.

Powdered replacement for liquid acids just introduced is blend of acid salts, activators, surfactants. Acid solutions prepared by dissolving in water. Suggested for activating metals before plating, and as pickling agent. **No. 1410**

Barium chloranilate reagent powder for sulfate determinations is now being marketed. Reduces working time to one half hour maximum, it is claimed. Suitable for analyses of water, petroleum products, many other materials. **No. 1411**

New gamma-sensitive scintillation detector is specially designed for medical diagnostic use of radioisotopes. Is said to be ideally suited for thyroid or kidney function studies, cardiac output determinations, 3-D body scanning. **No. 1412**

Feed industry outlook for next 50 years — covers expected advances in farm economics, biochemical developments, feed automation, liquid supplements, etc. in reprint form. **No. 1413**

New rauwolfia alkaloid raubasine is now available in commercial quantity. Product is also known as ajmalicine, delta-yohimbine and tetrahydroserpentine. **No. 1414**

High purity 2-butene and 1-butene concentrates are now commercially available. The 2-butene contains no isobutylene, 0.5% max. 1-butene, 1% max. butadiene, 96% min. 2-butene, balance n-butane. The 1-butene contains 5% max. isobutylene, 60% min. 1-butene, balance butanes. **No. 1415**

Disposable-paper temperature indicators for 100, 105, 110°F can now be obtained. Work by irreversible color change. Developed for measuring temperatures attained by heat-sensitive biologicals, etc. in storage and transit. **No. 1416**

Cholesterol's chemistry, biochemistry and pathology are detailed in a new, 542-page book which can now be purchased. Prepared by an international group of authors, book gives complete picture of present knowledge on compound. **No. 1417**

Small-capacity pump or meter designed to fit conventional laboratory stirring motor drives is now on market. Mounts on same ring stand as such motors. Said to handle small flows of Chemical liquids, slurries, pastes. **No. 1418**

Proceedings of Sixth International Conference on Spectroscopy (May 1956) have recently been published as a supplement to Spectrochimica Acta, 1957 and offered for sale. Includes papers on UV absorptiometry, IR spectroscopy, emission, spectrometry. **No. 1419**

PRODUCTS OF U.S.I.

Pharmaceutical Products: DL-Methionine, N-Acetyl-DL-Methionine, Urethan USP, Riboflavin USP, Intermediates.

Alcohols: Ethyl (pure and all denatured formulas); Proprietary Denatured Alcohol Solvents SOLOX®, FILMEX®, ANSOL® M, ANSOL PR.

Organic Solvents and Intermediates: Normal Butyl Alcohol, Amyl Alcohol, Fusel Oil, Ethyl Acetate, Normal Butyl Acetate, Diethyl Carbonate, DIATOL®, Diethyl Oxalate, Ethyl Ether, Acetone, Acetoacetanilide, Acetoacet-Ortho-Chloranilide, Acetoacet-Ortho-Toluidide, Ethyl Acetoacetate, Ethyl Benzoylacetate, Ethyl Chloroformate, Ethylene, Ethyl Sodium Oxalacetate, Sodium Ethylate, ISOSEBACIC® Acid, Sebacic Acid, Urethan U.S.P. (Ethyl Carbamate), Riboflavin U.S.P., Pelargonic Acid, 2-Ethyl Heptanoic Acid.

Heavy Chemicals: Anhydrous Ammonia, Ammonium Nitrate, Nitric Acid, Nitrogen Fertilizer Solutions, Phosphatic Fertilizer Solution, Sulfuric Acid, Caustic Soda, Chlorine, Metallic Sodium, Sodium Peroxide, Sodium Sulfite, Sodium Sulfate.

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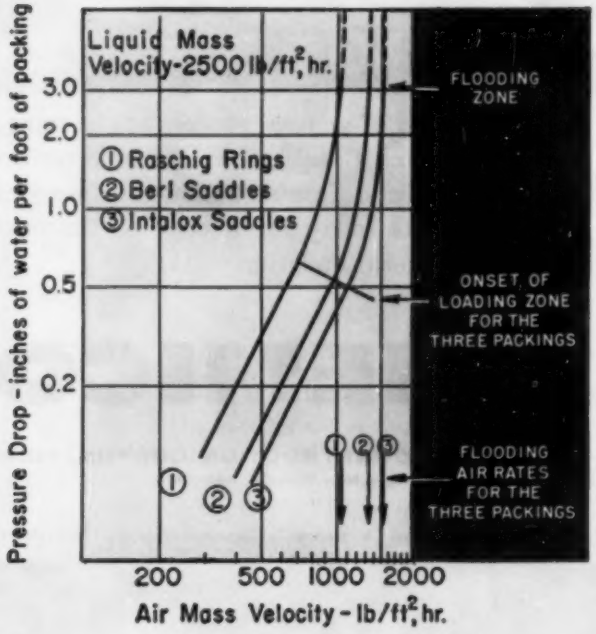
How to increase throughput through your PRESENT packed columns

If your present packed columns are using either Raschig Rings or Berl Saddles you can increase throughput substantially by re-packing your towers with Intalox Saddle packing.

The data in the accompanying chart show typical pressure drop, loading and flooding points for all three packings in the 1" size, all operated under a liquid irrigation rate of 2500 lbs./ft.^{2} hr.

You are ahead with Intalox Saddles in any way you operate your tower. Should you prefer to work substantially below the loading point, say at a gas rate of 500 lbs./ft.^{2} hr., your pressure drop savings as compared to Raschig Rings would be about 65%, and as compared to Berl Saddles, about 25%. Should you wish to operate in the low loading range, as many towers are being operated, you will be able to pass about 50% more gas through the tower, as compared to Raschig Rings; and about 15% more gas as compared to Berl Saddles. And these higher flow rates are realizable at a pressure drop that may actually be lower than you would have with Raschig Rings or Berl Saddles. Of course, the ultimate flooding limits of Intalox Saddles are also higher than for the other packings.



Like to know more about INTALOX SADDLES?

Write for a copy of Bulletin S-29 —full of data every engineer who is concerned with lower cost, more more effective packed tower operation needs. Address Dept. CEP 1158, The U. S. Stoneware Co., Akron 9, Ohio.

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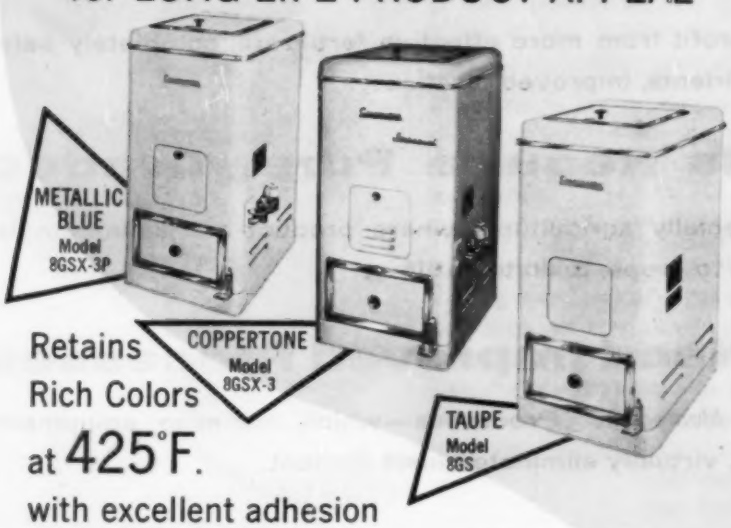

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about our authors

William C. Goggin, co-author with **E. E. Ziegler** of *Plastic Construction in the Chemical Process Industries,* joined Dow Chemical in 1936, since 1943 has been manager of the company's Plastics Technical Service Department. In 1945, Goggin assisted the War Department in its investigation of the German plastics industry. As a result of this experience, he co-authored the book *German Plastics Practice.*

W. O. Binder, assistant director of development for Electro Metallurgical Co., and author of this month's paper on *Stainless Alloys—Present and Future,* was awarded the Henry Marion Howe Medal by A. S. M. in 1950 for his work on extra-low carbon stainless steel. He is also co-author of a book titled *Boron, Calcium, Columbium and Zirconium in Iron and Steel* (John Wiley & Sons, 1957).

L. J. Barron (*Titanium and Zirconium in Chemical Plant Applications*) is a member of the titanium application development section in Du Pont's Pigments Department, has been closely associated with titanium application research since 1952.

(l. to r.) Authors Barron, Binder, Goggin

H. R. Ogden, author of *Future Metals,* is presently affiliated with Battelle Memorial Institute, Columbus, Ohio.

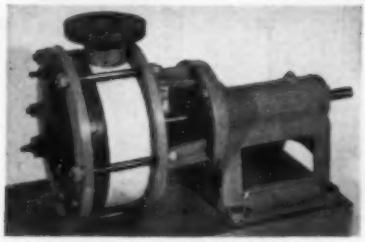
F. L. LaQue, whose article on *Corrosion Mechanisms and Materials Selection Methods* is one of the highlights of CEP's special feature section on construction materials this month, is presently vice-president and manager of the Development and Research Division for International Nickel. LaQue's interest in corrosion goes back to 1935 when he founded International Nickel's Kure Beach—Harbor Island Marine Corrosion Research Station near Wilmington, North Carolina.

E. A. Gulbransen, of Westinghouse Research Laboratories, contributes an original point of view in his paper on *New Ways to Look at Corrosion Processes.*

continued on page 32

VANTON *notes on fluid handling*

PUMPS • PIPE • FITTINGS • VALVES



BRAND NEW: PVC CENTRIFUGAL PUMP. For acids, caustics, pharmaceuticals, lithographic, plating, and all other kinds of sensitive solutions, Vanton's new PVC pump offers a low-cost answer. Constructed with all liquid-exposed parts of unplasticized, unmodified polyvinyl chloride, these pumps are simple to maintain, and are generally lower in cost than competitive special-alloy pumps. Size range: 10 - 180 GPM. CIRCLE ITEM 12.

PLASTIC GATE VALVES NOW AVAILABLE WITH SOCKET-WELD ENDS. A complete line of socket-weld Flex-Plug Plastic gate valves, extending the present line of screwed-end valves, is now available from Vanton in sizes from ½"—2" in both PVC and styrene-copolymer. The Flex-Plug valve, first of its kind, offers the combined features of straight through no-pressure-drop flow with close throttling control. The combination of these two features of a gate and globe valve makes the Flex-Plug one of the most versatile available. Now, with the addition of socket-weld ends, the unique plastic Flex-Plug valve can be used on the most severe services in the chemical, pharmaceutical, photographic and other industries. CIRCLE ITEM 11.

Vanton Pump & Equipment Corp., Hillside, N. J.
Please send booklet circled: **10 11 12**
My problem liquid is _____
NAME _____
TITLE _____
FIRM _____
ADDRESS _____
_____

Sealless Pump Proves Answer to Quality Plating of Grid Wire

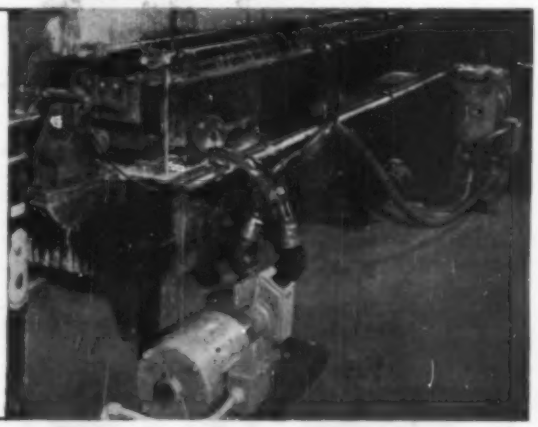
Rejections of silver-plated electronic tube grid wire due to porosity and blackening of plating surface are no longer a problem with engineers at the Wilbur B. Driver Company plant in Newark, N.J., since they discovered that a Vanton sealless plastic pump eliminates the causes. Driver, a manufacturer of quality precision alloy wire, had before this time been confronted with periodic plagues of rejection, foaming of plating solution, pump leakage, shaft scoring, and excessive packing maintenance.

Driver engineers finally traced the trouble to liquid leakage through the packing of the conventional metal pumps then used. This caused not only excessive deterioration of packing, but also scoring of pump shafts through crystallization of salts from the concentrated solution. Furthermore, air entering the pump through the deteriorated packing was causing the silver-plating solution to foam and deposit a porous finish. Constant preventive maintenance of the stuffing-box packing units was tried, but did not solve the problem for more than short periods of time. Increased operating costs and production interruptions remained a plague.

When Vanton plastic sealless pumps were installed, these problems ceased at once. Porous finish, excessive packing maintenance, and resultant production interruptions are no longer a problem. Entry of air bubbles through packing is eliminated, because there is no packing in Vanton pumps. Crystals formed in the solution do not wear Vanton pump components, because their abrasive action is absorbed by the resilient flexible liner. And of course, because the Vanton pump *has no* stuffing boxes or shaft seals, stuffing-box maintenance and shaft seal leakage are gone for good!

Pump capacities range from ⅛ to 40 GPM. Liners and housings are made in a variety of plastic materials, to suit a wide range of corrosive, acid, and slurry conditions. CIRCLE ITEM 10.

Vanton sealless plastic pump handles a tough assignment to help eliminate leakage, shaft scoring, and other plating problems at Wilbur B. Driver Company plant in Newark, New Jersey.



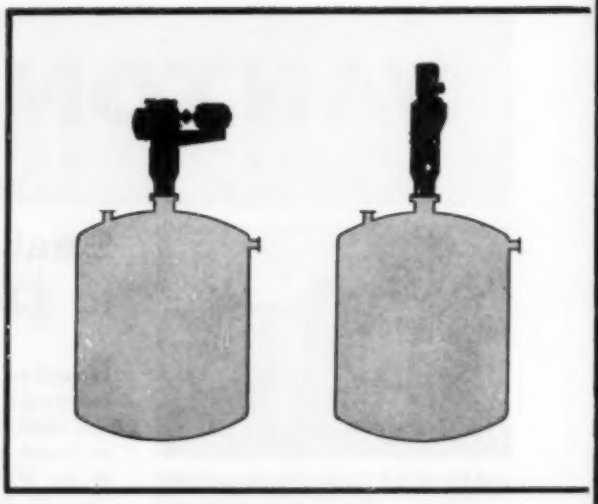
VANTON PUMP
and Equipment Corp. • Hillside, N. J.
DIVISION OF COOPER ALLOY CORP.

Q. If headroom is no problem, do vertical motor mixer drives have any advantages over horizontal motor units?

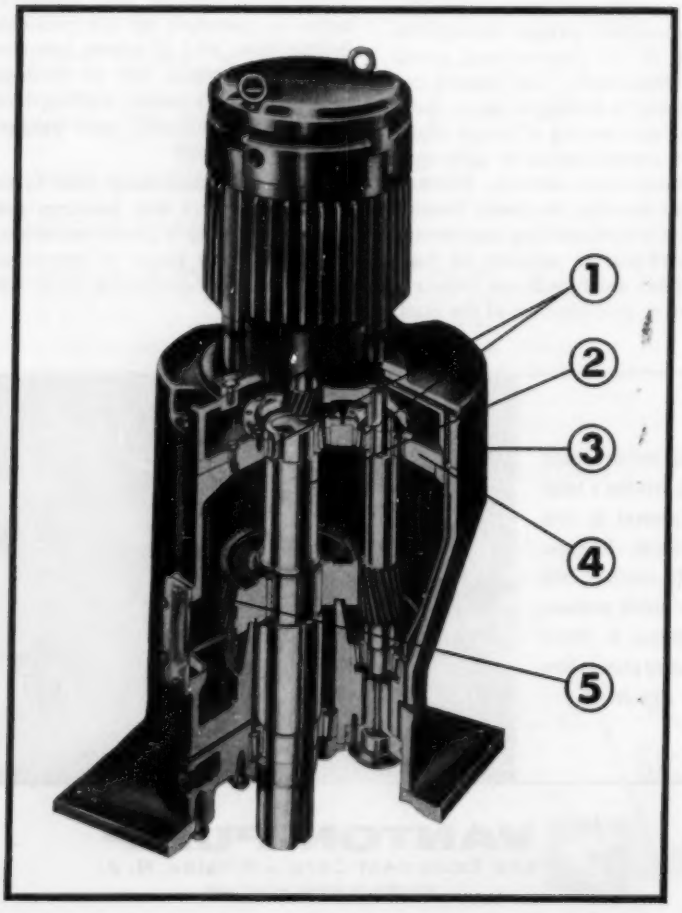
A. Philadelphia horizontal motor "3800 Series" and vertical motor "MV Series" both have the same high quality construction. From the standpoint of performance, drive efficiency and life expectancy, they are equal. However, each type has certain inherent advantages.

"3800 Series" units have an advantage in operating and mounting flexibility to meet changing process requirements. Change-gear sets are easier to install. Motors are somewhat easier to replace and horizontal drives can more readily utilize special motors such as variable speed types. Headroom requirements for the "3800 Series" are minimum for maximum bearing span. On the other hand, horizontal motor drives occupy more room immediately above the tank top and stresses imposed upon mounting nozzles by the overhung motors can require extra drive support . . . especially in the larger sizes.

"MV Series" vertical motor units have an advantage in that they occupy much less space at tank top, making it easier to install process piping. Better access to the tank is provided. Supporting difficulties are minimized because vertical drives are better balanced. While vertical motor drives are less flexible for a quick change of motors and output shaft speed, their greater inherent design simplicity makes them a more economical offering. They will usually be a sound choice when adequate headroom is available.



it's questions like these . . . that get

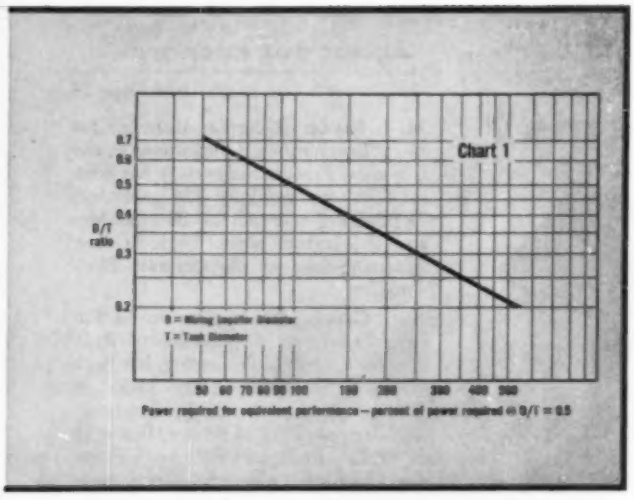


Q. What design factors insure maintenance of drive shaft alignment, even after years of operation?

A. The ability of a shaft to run dead-true, through years of operation, depends primarily upon the design approach of the manufacturer. When extra large, extra high capacity bearings (1) are used, shafts (2) can be larger, stiffer, heavier duty. When other drive components . . . housings (3) bearing supports (4) and gearing (5) . . . are designed for extra strength, shafts will be supported with near-absolute rigidity. Result: damaging shaft deflection simply cannot occur. Gearing is effectively isolated from unbalanced loads.

You will get truer shaft operation at shaft seals.

Whenever alternate offerings are being evaluated . . . and if price and output torque ratings are competitive . . . then the basic design approach of each manufacturer demands careful examination if you are to get full advantage of the savings that result from better performance, less maintenance and longer life.



Q. Are "dollars per horsepower" a valid basis for comparing mixer values?

A. No. Mixers having the same horsepower rating and drive efficiency can vary widely in torque rating. Torque applied to the mix is what does the work and torque is what you pay for. When comparing mixer values, the most important first step is that of developing torque ratings of alternate units offered. Using the most familiar units, torque can be calculated as follows:

$$\text{Torque (lb. inches)} = \frac{63025 \times \text{Motor HP}}{\text{Mixer shaft RPM}}$$

The mixer having the lower torque rating must use a higher mixer shaft speed and smaller diameter impeller to maintain a given level of mixer output. This can lead to unsatisfactory performance. However, a mixer of equivalent horsepower rating but with a higher torque rating and larger impeller will do the job well. For an idea of the importance of impeller size, the chart shows the influence of impeller diameter in relation to tank diameter (D/T ratio) upon motor HP required for a specific level of performance in many industrial mixing operations. The bigger impeller at the slower speed (higher applied torque) will be a sounder choice.

down to basics in buying mixers . . .

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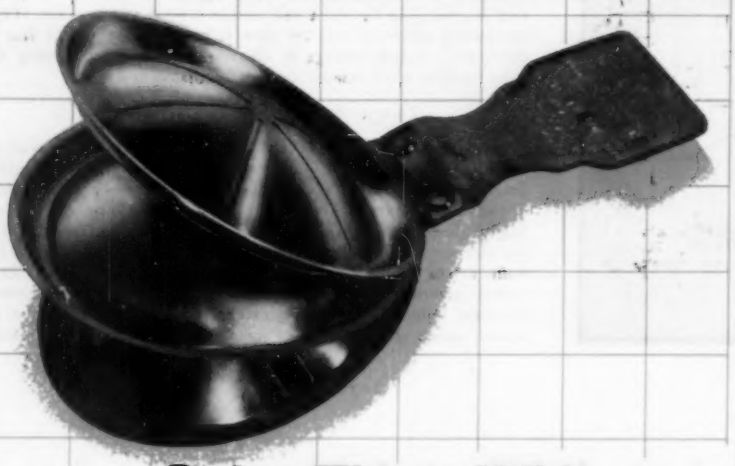

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about our authors

from page 28

M. J. Snyder (*Ceramic Materials for High Temperature Applications in the Chemical Process Industries*) has been involved in ceramic and chemical engineering research at Battelle Memorial Institute since 1941, is now assistant chief of the Ceramic Division.

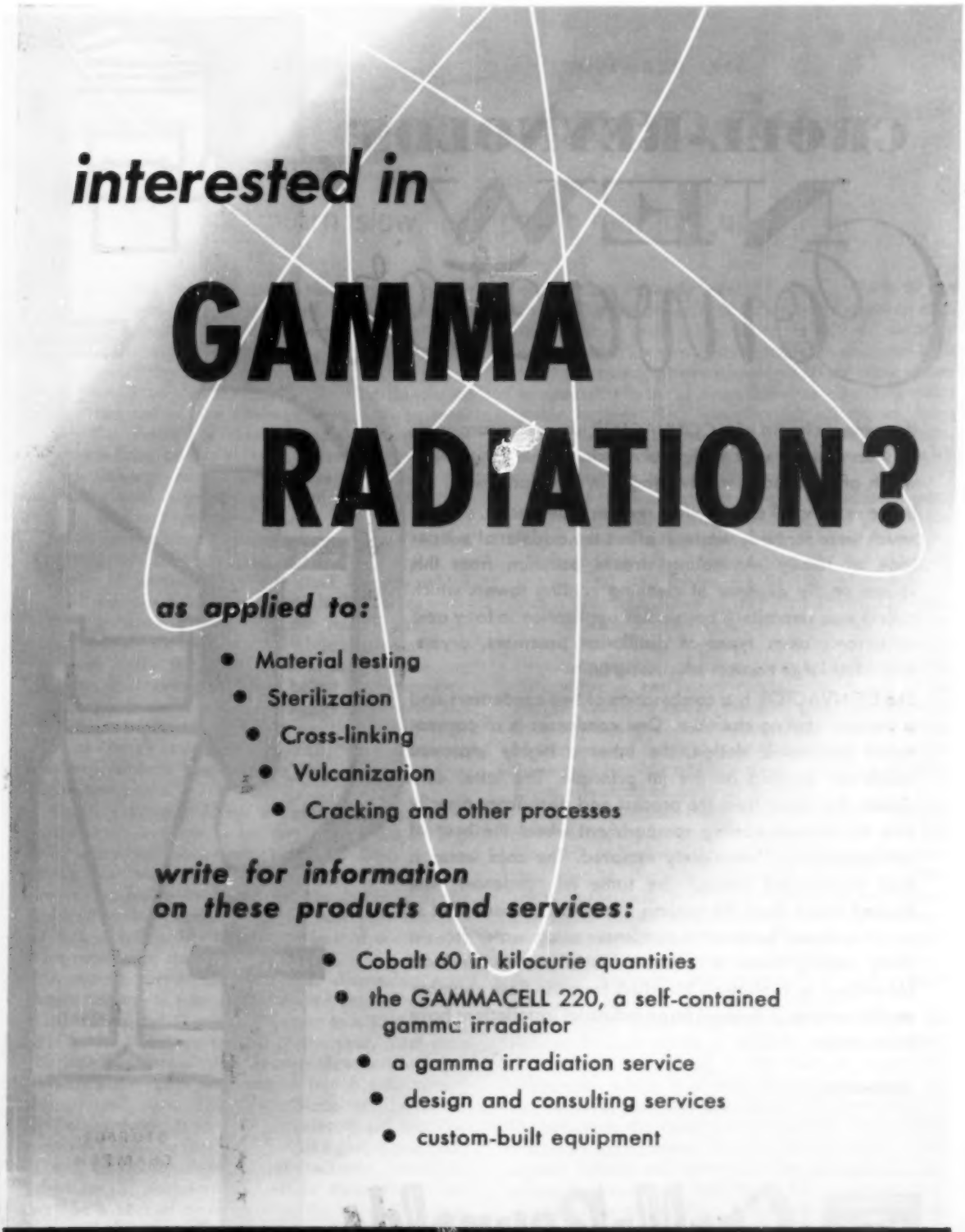
B. S. Garvey, Jr., who writes on *Future Trends in Application of Rubbers for Chemical Processing*, has been engaged for some thirty years in studies on the chemistry, synthesis, and compounding of rubber, first with B. F. Goodrich, and then with Pennsalt Chemicals, where he is now manager of the Rubber Sales Service Laboratory for Sharples Chemicals, a division of Pennsalt.

(l. to r.) Authors Aronson, Pierce, Stephens

J. E. Pierce, who writes this month on *Evaluating the Need for a Pilot Plant*, has been with Dow Chemical since 1929, in research and engineering. His present title is pilot plant coordinator.

E. R. Stephens, presently group leader for air pollution research in the Chemical Kinetics Branch of the Franklin Institute, collaborated with **E. A. Schuck** of Stanford Institute in the research project the results of which are reported in this month's CEP article on *Air Pollution Effects of Irradiated Auto Exhausts as Related to Fuel Composition.*

David Aronson (*Preliminary Design Studies of Low Temperature Refrigeration Plants*) first became actively interested in low temperature work at the Elliott Co. where he was a member of the process group which developed the low pressure tonnage oxygen cycle using a single column and a separate nitrogen refrigerant stream. He is presently a staff consultant with the headquarters engineering organization at Worthington Corp. One of his spare time assignments is taking care of inventions submitted by outsiders. He, "finds my knowledge of thermodynamics still inadequate to convince the ardent amateur that all the advances in chemistry and physics still bring us no closer to the perpetual motion machine."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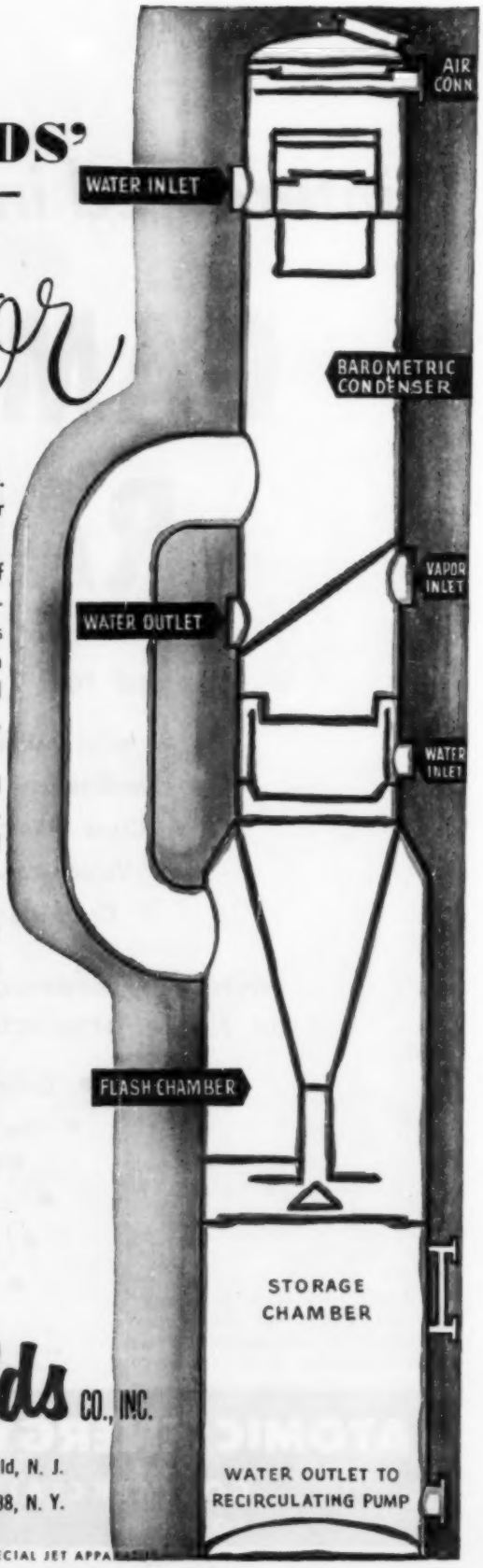
CROLL-REYNOLDS' NEW Convactor

If you never heard of a CONVACTOR, do not be surprised. It is an entirely new design of special condensing tower which offers important advantages in some processes.

In the refining of edible oils it recovers fatty acids, most of which were formerly waste. It offers the additional advantage of totally eliminating stream pollution from this source or the expense of cleaning cooling towers which collect such deposits. It has similar application in fatty acid stills, some other types of distillation processes, dryers, and other large vacuum processing units.

The CONVACTOR is a combination of two condensers and a vacuum cooling chamber. One condenser is of conventional barometric design, the other a highly improved condenser working on the jet principle. The latter condenses the vapor from the process and discharges directly into the vacuum cooling compartment where the heat of condensation is immediately removed. The cold water is then recirculated through the same jet condenser. The flashed vapor from the cooling operation is condensed in a conventional barometric condenser using water from a river, cooling tower or other industrial source. Periodic blow-down or continuous bleed-off from the flash chamber permits recovery. Several large industrial installations have been made.

Patent applied for



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NOVEMBER 1958

CEP.....trends

Upturn slow, but profit margins up

As was hoped, business in the third quarter of the year continued to move forward, and sales in the chemical industry on the whole gained month by month. This improvement held up through October, even though the motor industry continued to run in low gear. It now seems established that the nation is moving out of the recession, although in some cases the motion is slow. Earnings reported by chemical firms, on the average, showed an improving trend, although most companies reported sales and earnings well below a year ago. Union Carbide Corp., in the September quarter, actually showed slightly larger earnings than a year ago—$1.15 a share against $1.13 a share, due chiefly to a pick up in sales of ferro-alloys to the steel industry which had been down sharply. Carbide looks for continued improvement through the end of the year. Du Pont, on the other hand, while showing better earnings in the third quarter than in the preceding quarter, was nevertheless well below the September, 1957, quarter. Du Pont management commented that the company appeared to be "through the bottom of the recession," but added, "we do not see any real upturn but we don't see any downturn right now either."

One encouraging factor is that demand for 1959 automobiles appears to be very good even though production and shipments have still been at low levels. The continued high level of consumer income seems conclusive evidence that the public did not hold off motor purchases in the past year because of lack of funds, but because of lack of confidence. This confidence should return swiftly.

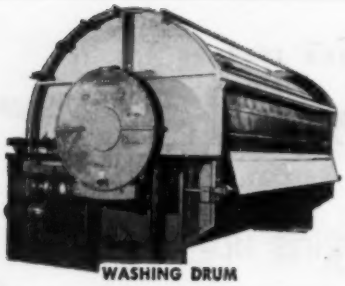
A recent survey indicates that disposable consumer income is now at the record rate of around $310 billion, and is expected to rise to a $315 billion rate in the last three months of the year. Next year the rate will probably be even higher, indicating a surplus above 1957 sufficient to buy 6 million medium-priced cars. This leads some of the more optimistic prophets to look for sales of automobiles next year to reach that level. If this figure is reached, it will obviously have a tremendously favorable effect on the economy and might mean that 1959 may be a year of record prosperity, as well as one that will point up the serious need for expediting major highway construction.

One interesting and favorable result of the recession, which was sudden and sharp though short-lived, was that business made a notable job of cutting costs and raising operating profit margins. An outstanding example was U.S. Steel, which to the surprise of the financial community was able to earn its dividend even when down to 50% of capacity operations. This would seem to indicate a new high level of earning power when operations come closer to normal. Chemical firms have, of course, a more stable business, but also, through economies, have raised their profit margins by substantial amounts, and therefore can and do show better earnings with only moderate sales improvement.

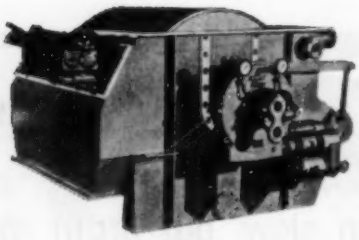
Part of these economies have of course been managed by the drastic means of firing that part of the help regarded as marginal and, in some cases, inefficient. One big chemical producer for example, cut its total staff by more than 15% below what it was a year ago. None of this curtailment, however, was in what it considered key personnel, and involved few if any engineers. Now the company is beginning to think of turning around and increasing its number of employees carefully so as not to be caught short-handed as business gains continue. It now appears probable, taking into account these economies and the higher profit margins, that a few firms may be able to show record earnings in 1959, given a year about as good as 1957.

On the political front, the feeling in business circles is generally that the Democratic party is less favorable to business than the Republican. However this may be, there has obviously been great prosperity in the past under Democratic administrations, and under Republican administrations legal attacks on business—witness the Du Pont case—have not been infrequent. An increasing, and distressing, trend is seen in moves by State governments to raise taxes both on individuals and on corporations.

One major factor in government spending is the defense budget which is unlikely to be cut. Here expenditures are taking a new tack. A major development, which is already having an impact on the chemical industry, and which will have more in the future, is the trend toward missiles and rockets and away from manned military aircraft which some experts believe will eventually be eliminated. This brings the matter of new fuels and changing fuel requirements to the fore. Only recently, there has been a swing away from liquid oxygen to nitrogen tetra-oxide which has already had repercussions on some divisions of the chemical industry. The budget for fiscal 1959 for missiles and rockets has been set at $6.5 billion, up from $2.3 billion in the preceding year.

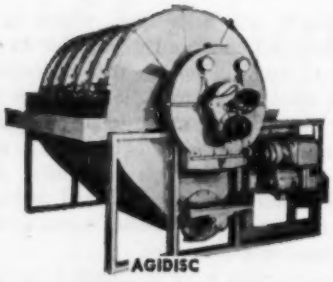


WASHING DRUM



PRECOAT

ROTOBELT



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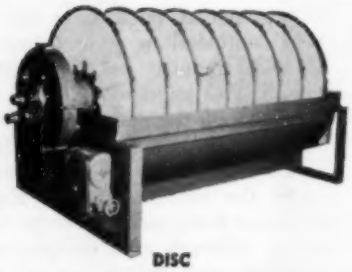

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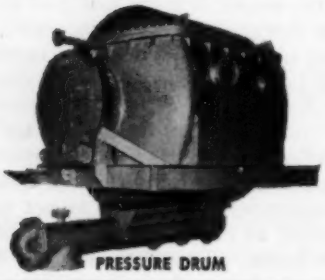

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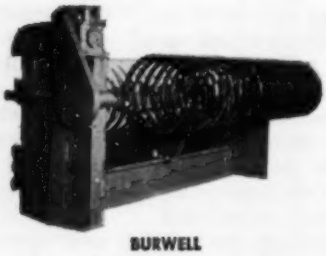
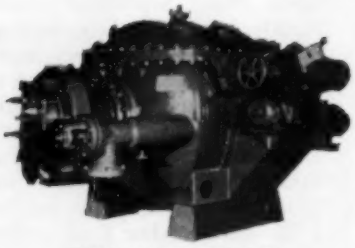
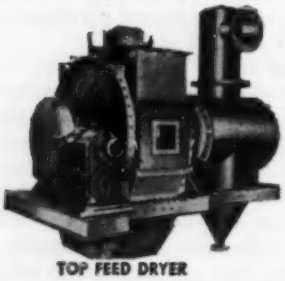


BURWELL



PRESSURE PRECOAT DRUM



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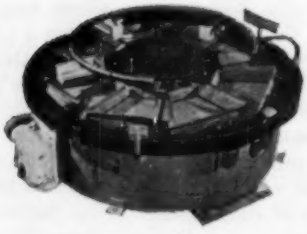

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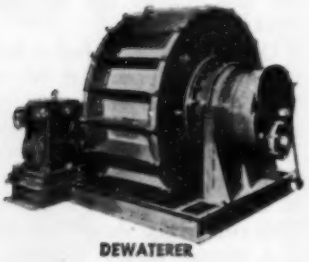
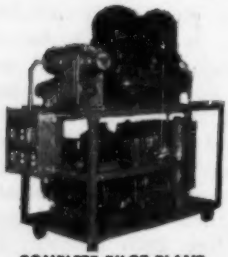


DEWATERER



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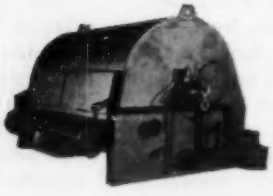

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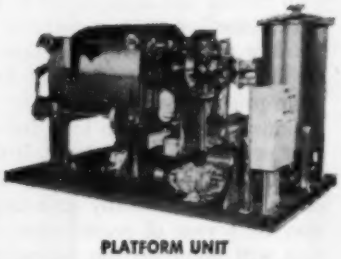

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opinion and comment

Chemical engineering in Britain; Heavy demand?

The Institution of Chemical Engineers, British counterpart of the A.I.Ch.E., has issued an analysis of employment of chemical engineers in Great Britain. This follows the publication in 1956 of a government survey of scientific and engineering manpower, and in 1958 of a "Survey of Output of Chemical Engineers in G. B." by the Institution.

Among the many interesting facts in this new analysis are those having to do with changes that have taken place since an earlier survey (1953). Although the methods of analysis used in the 1957 survey are said to be more refined, nevertheless, "there does appear to have been some increase in the proportion of members employed in administration (1953=20 percent; 1957=30 percent), together with a decline in the proportion engaged in plant operation (1953=23 percent; 1957=12 percent). . . ." Comparison with the most recent figures available from the United States on employment in R & D, gives a low figure in Britain: "Great Britain=23 percent; U. S. A.= 31 percent." On the other hand, the percentage employed in design, construction, installation, and "commissioning" is high: "Great Britain =27 percent; U. S. A.=7 per cent."

One of the surprising things brought out by the Institution's survey is that the oil refining industry now has the greatest concentration (chemical engineers per 1000 adult males employed) of any industry group, 7.3; with the runnerup, fine chemicals including pharmaceuticals, at 4.9; and the combination of dyes and dyestuffs, fertilizers, synthetic resins and plastics, and heavy chemicals now totalling only 2.6. In commenting on this, the Institution's analysis says: "It is appreciated of course that the concentration of chemical engineers must (by) necessity vary from industry to industry. Nevertheless, the figures indicate that the . . . oil industry has been more successful than some in building up an adequate corps of chemical engineers. It may not be going too far to say that some industries do not appear to have a proper appreciation of their needs for chemical engineers. This may be the reason why the (government's) Manpower Report does not indicate a much greater total increase in the number of chemical engineers required by 1959."

The (British) government's report gave the total number of qualified chemical engineers in Britain in 1956 as 1500, and the total number required by 1959 as 2200. The analysis reports, however, "It has been estimated on behalf of the Institution that the total population of qualified chemical engineers in Britain by 1956 should have been of the order of 5,000, and that this should increase to 10,000-11,000 by 1966." If the Institution's own estimate of output of chemical engineers from universities and technical colleges—around 900 per year by 1966—is met, "then," the analysis continues, "the needs of expansion and replacement may be met, though it is unlikely that the present shortage of qualified men will be made good by that time."

Comments on the degree and nature of the present shortage recall some of those heard recently in the United States: "The 1956 apparent shortage—the difference between 1500 and approximately 5,000—does not mean of course that there are or were 3500 vacant chemical engineering posts in industry. A good deal of chemical engineering work is being done by persons who have some, often narrow, chemical engineering experience, but who are not academically or professionally qualified in the subject. On the other hand, discussions at the Joint Symposium on the Organization of Chemical Engineering Projects (to be published) emphasized the need for more intensive and detailed planning before construction is started. Such planning makes heavy demands for qualified men if it is to be really effective. *There is obviously no room for complacency.*"

The similarity of the problem in the field of supply and employment of chemical engineers in both the U. S. and Britain, makes this subject worthy of careful consideration. J. B. M.

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S. J. MILLER – SALES ENGINEER

After graduation from Massachusetts Institute of Technology with a BS degree in Chemical Engineering, Miller spent five years in process design and production supervision, including equipment specifications, economic evaluations of processes, and plant start-ups.

Miller has been a Sales Engineer with National Carbon Company since 1953. Knowing chemical plant corrosion problems from actual experience, Steve Miller is well equipped to assist engineers and plant operators on the application, design and installation of carbon, graphite and "Karbate" impervious graphite process equipment.

New Activated Carbon finds extensive use!

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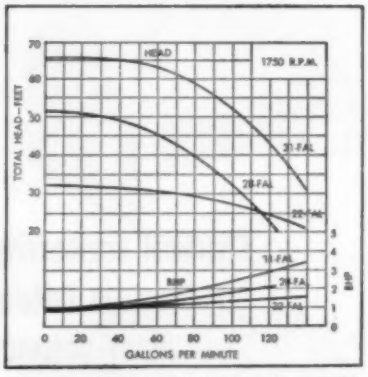
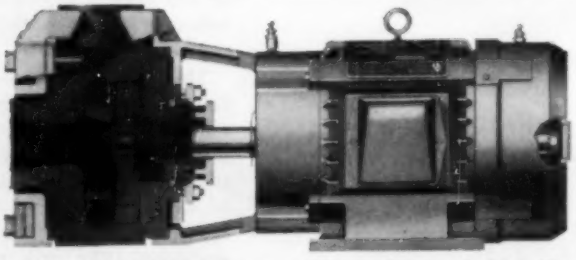
"KARBATE" PUMP LINE EXPANDED!

Three new sizes of Model F Centrifugal Pump extend Capacity and Head

Three new sizes of Model F "Karbate" impervious graphite pumps are now available to meet the demands of the chemical and metal finishing industries for greater capacities and heads. These are designated as Sizes 22-FAL, 28-FAL, and 31-FAL. Operating at 1750 RPM, capacities up to 150 GPM and heads up to 67′ can be obtained. To handle fluids with specific gravities greater than water at the higher capacities and heads, the 28-FAL and 31-FAL pumps are available with 3 and 5 horsepower motors. The chart on the right shows performance curves for the new Model F "Karbate" centrifugal pumps.





Model F "KARBATE" Pump withstands rough handling

A Model F "Karbate" impervious graphite pump has operated successfully for three years in a large refinery's portable equipment cleaning unit. The "Karbate" impervious graphite parts of the pump withstood the abuse normally encountered in this type of service. However, when changing the seal, the steel support casting was damaged. The body bolts were tightened so hard that the pressure broke the casting. The "Karbate" volute case and cover were not even chipped. Here is proof that "Karbate" impervious graphite pumps are built to "take it" and that the armored design minimizes the possibility of damage even under the most severe operating and poorest maintenance conditions.

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National Carbon Company can produce and supply all styles of porous carbon filter tubes for tube type filtering equipment. Tubes having any I.D. and O.D.'s up to 6⅝" with lengths up to 36" can be manufactured from available stock. In addition, Grade 40 porous carbon filter tubes, Style B, 2⅛" I.D. x 4½" O.D. x 36" long are in stock for immediate delivery. Sizes and prices of porous carbon filter tubes will be supplied upon request.

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UNION CARBIDE

Plastic construction in the chemical process industries

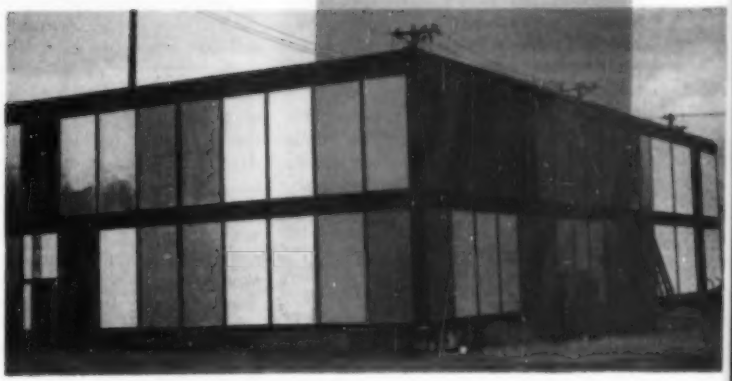

Figure 10. Structural sandwich panels—foam plastic cores, various skins.

W. C. Goggin, E. E. Ziegler* *The Dow Chemical Company, Midland, Michigan*

United States increase in population and in gross national product, as well as the growth of industry, has been supported by a tremendous expansion of the chemical industry in the past twenty-five years. It is probable that the growth of the next twenty-five years will be even more striking.

Wars, national emergencies, the shortage of raw materials, the unavailability and high cost of skilled labor, and the needs for stretching capital as far as possible have all accelerated the search first for substitute, but subsequently for better, more useful, and cheaper materials for construction. It was only natural that the synthetic materials, tailor-made for specific uses, were studied as potential solutions to these problems.

While expensive at first, the great increase in production of these tailored synthetic products with strong competition has lowered the prices to the point where they are often below the inflated prices of the natural products with which they compete. In some instances, the final installed cost of the synthetic product is well below previously used material because novel construction methods have reduced the labor requirements.

Thus, there are several reasons for the expanded use of plastics in building. The economic reasons include weight reduction, simplification of transportation, ease of installation, lower installed and maintenance costs, greater availability, expanded utility, and longer life. In addition, there are the aesthetic reasons of color, texture, pattern, flexibility of design, and new concepts in architecture.

In the light of this background, it is planned to examine the construction of a chemical process unit from the shell of the building, through the chemical equipment, through the decoration of the building, and finally through unique new buildings of use to the chemical process industries.

The extent to which plastic materials have penetrated the construction industry can be shown graphically by comparing plastics in construction to a tree that gets its growth from roots based on plastic raw materials, while the trunk represents the full flow of these products into the building industry. This synthetic tree has branches comparable to several major grafts. The first and oldest portion of the tree is based on the well-known thermosetting plastics. This includes phenol formaldehyde, melamines, ureas, and the newer epoxies, polyesters, and polyurethanes. These products entered the building industry in 1957 at the rate of 241 million pounds per year. The largest single volume product of the group was phenolics at 163 million pounds. The next major portion of the tree lists the special types of plastic materials which are now being used in the construction industry. These include silicones, synthetic latexes and ion exchange resins. They entered the industry at the rate of 28 million pounds per year in 1957. Finally, the major branches of the tree are made up of a graft, related to thermoplastic materials. This includes polyvinyl chloride at 170 million, polystyrene at 93 million, and polyethylene at 98 million pounds per year. In addition, the cellulosics, acrylics, saran, and others go to make up the remainder of the 414 million pounds of thermoplastics going into building in 1957. These various segments of the tree comprised the full volume of plastic trade that flowed through the trunk and reached the building industry in 1957 at 683 million pounds per year (see Figure 1).

The construction of chemical process buildings

To best visualize the part that plastic materials have played in the construction of buildings for the chemical process industries, actual applications will be used. It would be possible to attempt a forecast of the future uses of plastics in the chemical process

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... foundation protection, translucent panels, explosion blowout panels, skylight panels, are only some of the growing uses for various plastic materials in building construction in the chemical industry.

industries, but rather than speculate, the choice has been made to emphasize and review in detail some of the successful applications of these materials in chemical construction. It is planned to follow this construction from the foundation through the walls and the roof of the structure. Then the processing equipment and furnishings will be added and finally new types of useful buildings will be studied.

Ethylene film as a vapor barrier

In the foundation (Figure 2), polyethylene film as a vapor barrier is laid underneath a concrete slab which forms the floor of the building. Around the perimeter of this building is placed boards of polystyrene foam. They serve as an excellent moisture barrier, but more particularly as perimeter insulation controlling the loss of heat from the building. In more complicated forms of construction, a flexible polyvinyl chloride sheet as a waterstop in a reinforced concrete base might be found desirable. This not only serves as an expansion joint between solid slabs, but as a barrier through which water or even corrosive chemicals cannot penetrate.

Once the slab is poured, its use may call for properties beyond those normally attributable to otherwise adequate floors. For example, in the case of maple top flooring badly damaged through use in a warehouse, the damaged flooring was removed, the base brushed with a styrene-butadiene latex which was allowed to dry overnight to form a moisture barrier, then a half-inch layer of sand, cement, and water latex mix was laid over the base floor. Finally the floor received an additional half-inch layer of concrete with the water replaced by a 50-50 latex/water mix. The floor after one year's use looks excellent in spite of the continuous traffic of fork lift trucks with heavy loads.

The use of plastic materials in the outer walls of a chemical construction building have been largely limited to translucent panels and special plastic sandwich panels. In many cases translucent panels above the windows are polyester-faced with a honeycomb-type core. Also, the outside walls of many buildings have plastic panels above each window, based on a reinforced polyester skin on either side of a foamed polystyrene core. When seen from the inside it is obvious that this sandwich panel core above the window is good for the transmission of diffuse light, thus improving the illumination of the room.

Transparent and translucent plastic panels are used in increasing amounts for glazing. Examples of specialized acrylic windows are often seen in a chemical laboratory building. This special shape is designed to provide diffuse light without excessive heat. Another method of using corrugated vertical glazing was demonstrated by a recent British building. Here the plastic matches the corrugated metal building siding. One valuable use of plastic materials in certain chemical process buildings might be an explosion-blowout panel. Light-stable cellulose acetate butyrate panes are relatively shatterproof and the whole window blows out should an explosion take place.

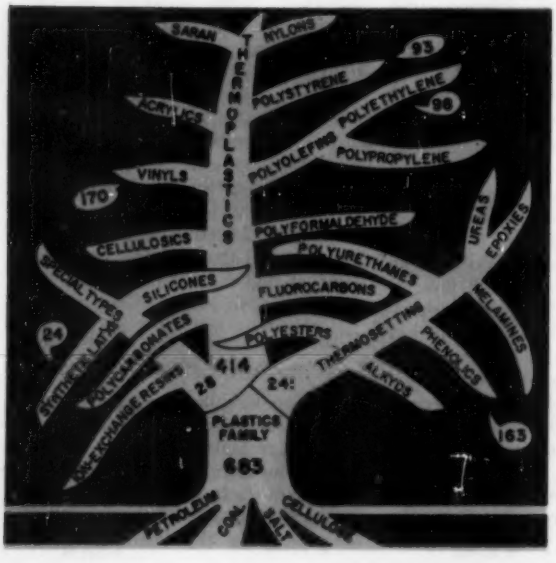

Figure 1. Plastics family tree indicating the volume of plastics, in millions of pounds, consumed by new construction in 1957.

Light transmitting walls and skylights

Large translucent panels of several types of plastic materials can be used for light-transmitting walls. Some plants use corrugated glass reinforced polyester panels on a vertical wall for weather protection yet with ample light transmission. In Figure 3 polyvinyl chloride in ⅛ in. thick translucent sheet is being installed here as a vertical skylight. It has given satisfactory service for a period of two years and has good chemical resistance in a highly corrosive atmosphere. An inside view would show the effective lighting obtained from the polyvinyl chloride glazing in this building.

Joining a flat and a corrugated surface along a wall line frequently offers a real problem. It requires a permanent waterstop or seal as well as an expansion joint. Sheet based on a flexible saran, a chemical resistant and highly flexible waterstop, can be used to join a dock roof to a vertical masonry wall. A useful finish for chemical buildings where leaching may be a serious problem is to apply a silicone water-repellent paint to the masonry after completion of the wall.

With the walls complete, attention focuses on the building roof. Glass reinforced polyester sheet serves as an industrial skylight. Another application for light-stabilized reinforced

Figure 2. Polyethylene film vapor barrier under a concrete floor slab and polystyrene foam as perimeter insulation and vapor barrier around foundation wall.

polyester skylights is to cover large open areas in the roof. Dome lights made from a white translucent or opal translucent acrylic material and vacuum formed make effective skylights for this British chemical office building (Figure 4). American acrylic skydomes effectively give permanent light transmission to spot areas through this roof structure.

Control of light is only one of the problems encountered in roof construction; control of heat becomes increasingly important when considering the radically new processes and the uniquely new materials. One effective method for making a strong and insulating roof is that construction based on several layers of polystyrene foam. The first layer is held to the joists using metal wires and plates. The second layer is then bonded to the first, and finally the system is covered with a built-up roof based on roofing paper and asphalt. This roof is most suitable for buildings with controlled inside temperatures, like refrigerated storage areas and coolers. Finally, the construction would not be complete without an adequate plastic flashing. For the more complicated flashing problems such as the base of this column as it extends through the roof to support a superstructure, a saran-based sheet provides a permanent water seal and expansion joint under the most adverse chemically corrosive conditions.

Processing

Plastic materials have entered into the chemical process field even more extensively than they have in the construction of chemical process buildings. Tanks, pipe, fittings, filter cloth, special containers, and transmission systems are only some of the many applications where plastic materials have displaced other less satisfactory products. Many polyester Fiberglas electroplating tanks indicate the value of plastic materials where nonconductive inert material is required. Laboratory sinks lined with chemically resistant flexible saran sheeting assure permanence of the sink even under the most severely corrosive conditions. Polyvinyl chloride in rigid form is successfully used as a tank and duct material for fume extraction in much English equipment.

From fume hoods it is natural to consider even larger rigid polyvinyl chloride ducting systems. The ducts lead to large ventilation stacks for hydrochloric acid fumes. The stacks often have a ½ in. thick base and the rest of 3/16 in. thick PVC sheet. Where needed, they are supported by PVC-covered steel. One plant has had seven years of severe service.

In some specialized applications, one finds large polyvinyl chloride ducts again for hydrochloric acid fumes, as at this English atomic energy plant (Figure 5). A portion of this duct work is transparent rigid polyvinyl chloride ⅜ in. thick so that the contents carried by this duct-system can be viewed. An unusual application is a specialized tank for use at higher temperatures. It is based on a PVC lining reinforced with polyester-bonded Fiberglas for the outer side. This tank has a removable filter of perforated PVC. PVC in its various forms has been used more extensively abroad than here. However, the United States is rapidly overtaking the European countries in the use of PVC for chemical resistance applications. For example, transparent rigid PVC tanks are often used in hydrogen peroxide tests. In this case the gasketing material of the tank is polytetrafluoroethylene. Another unusual combination is that of expanded metal embedded in transparent PVC. This permits the operation of the transparent PVC containers at high temperatures and heavier loads.

Chemically resistant linear polyethylene is already being used for tanks. In this application the four corners have been formed by heating and bending the flange to eliminate much of the welding. A bottom and one side seam is all that is necessary to complete the welded tank. The 1-in. flange around the open top and the reinforced beading on the sides add to the rigidity of the tank thus avoiding deformation when the tank is filled with liquid. In Figure 6 linear polyethylene filtration tanks are contained in a welded-steel support cradle and the tanks in turn contain linear polyethylene welded with threaded pipe for fluid distribution. A large tank, such as a 2,000-gal. tank, is lined with a special grade of polyethylene with high stress corrosion resistance. Here the polyethylene thickness is ¼ in. and all fitting is done by welded construction using hot gas guns. Even larger polyethylene tanks are made of ¼ in. sheet to hold acid effluent before neutralizing. Some of these larger tanks were built in 1951 and have performed satisfactorily since.

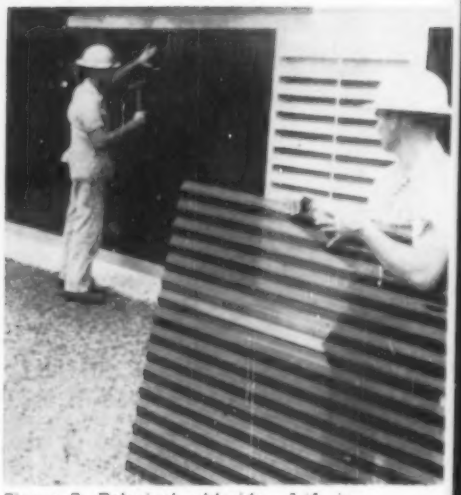

Figure 3. Polyvinyl chloride, 1/4 in. thick, translucent sheet as a vertical skylight.

Still another approach to chemical resistance of tank surfaces is used in some slurry-settling tanks. The original concrete tanks cracked and showed considerable corrosion. To repair them, polyester resin was applied to the concrete in the damaged area, then a layer of glass cloth, and more polyester was squeegeed on. A final coat of resin completed the lining of the tank.

Often plastic materials in the form of foams can be of value in insulating tanks when low temperatures are involved. Boards of polystyrene foam are used as an insulation on these

Plastic Construction

continued

tanks. With small diameter tanks the boards have to be cut or formed to size, while with large tanks the flat boards can be bent and strapped in place. Tank cars and trucks present applications where plastic materials have been used effectively as linings, as coatings, or as insulation. An English rail tank car has been covered with a flexible polyvinyl chloride, replacing the original exterior sheet steel covering. This is to prevent corrosion that took place from chemical exposure of the sheet steel. Tank trucks and trailers for hauling chemicals products often use plastic linings or in some cases may be completely made of reinforced plastics. Some units are a combination of stainless steel lining in a reinforced polyster resin tank.

Plastic pipe of many varieties presents major applications in the chemical process industry. Plastic pipe uses include both conventional and highly specialized applications. One of the more unusual is effluent drain pipe in Australia. The 1-ft. diam. built-up polyethylene pipe is 250 ft. long. The actual weight of this complete pipe is ⅛ ton, and it replaces stoneware that weighs more than 5½ tons. Joints are welded with a hot gas torch. The pipe is constructed in 9-ft. lengths, welded to 18 ft. in the shop. This length is relatively easy to handle in the field.

In another case, special sulfuric acid plant drainage pipe was constructed of heavy gauge polyethylene, and eventually installed in an English acid plant. In contrast, large quantities of polyethylene pipe in standard sizes are now being universally used in many industries. It has seen long service in farming and in the oil fields. It is rapidly gaining acceptance in the chemical industry. Its use minimizes labor costs since it can be easily cut with a knife and assembled with relatively simple and reliable fittings. Linear polyethylene is now molded and machined into special chemical fittings and valves such as a 1-in. globe valve. In this case, the plastic is strong enough so that the flange can be tightly threaded to the valve body with a very tight seal. Cellulose acetate butyrate has found use in the oil fields as brine-disposal pipe and in small-size gas lines in certain areas of the country. In one case a 4-in. acetate butyrate pipe is used as a 1,500-ft underground disposal line for highly acidic water from a gas well.

One of the problems encountered with all pipes, including plastics, is expansion and contraction. The coefficient of expansion for plastics is often ten times that of metals. One way to solve this problem is through the use of an expansion loop. The circular bend in one 2-in. diam. pipe is used to absorb movement in a 200-ft. line.

Figure 7 shows polyvinyl chloride, chemical resistant pipe, valves, and fittings, which are solving many plumbing problems. This network of 2- and 4-in. PVC lines is in service in an aluminum hydroxide plant.

A sound engineering approach to the problems of increased strength and heat resistance of plastics pipe is to use the inert plastic to line metal pipe and fittings. For years saran has been successfully used in this fashion. Even saran-lined pumps are now available for extreme chemical resistance at moderate temperatures.

Pump bases and foundations may present a special problem. As an example, corrosion on concrete leaves a pump with a much weakened foundation. The same pump base when protected with flexible saran-based sheet gives greatly extended life.

Underground pipe lines leading to a chemical process plant often need protection from corrosive soils. One solution to this problem is to use a mummy wrap of saran or polyethylene film and a protective kraft paper. In another case a water heater in a chemical plant had a section that had never been well maintained, and consequently corroded and broken walls resulted. This pipe was wrapped with glass cloth and polyester resin and cured to give a hard corrosion resistant surface.

Pipe which conveys liquids at high or low temperatures must be insulated for efficient service. Polystyrene foam provides an excellent insulation for these outside pipes.

Good finishes for the chemical plant, the laboratory, and the process equipment can save many maintenance dollars. In much chemical building PVC pipe is extensively used, and urethane-based paint is used on the structural steel to give the same order of resistance as the polyvinyl chloride pipe. Occasionally combinations of high temperatures and corrosion result in an especially involved problem. Often a heat-resistant, aluminum-pig-

Figure 4. Acrylic skylights for transmitting light to interiors.

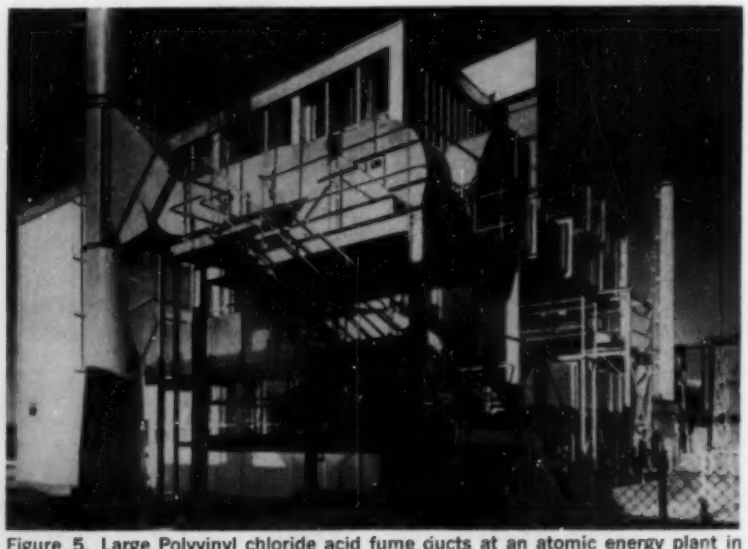

Figure 5. Large Polyvinyl chloride acid fume ducts at an atomic energy plant in England. A portion of this duct work is transparent so contents can be seen.

mented silicone paint is used on many Diesel exhaust stacks. A similar organic paint with aluminum pigment is used on others. Many exhaust stacks operate at temperatures in excess of 500°F. in a corrosive atmosphere. Figure 8 illustrates how a petroleum company has found the use of silicone-based paints extremely valuable on this catalytic cracker. After three years the performance of these paints places the plant in striking contrast with the otherwise colorless landscape.

Two other segments of the chemical plant have been improved through the use of plastics. They are evaporative cooling and waste disposal systems. Plastic packings for cooling towers and waste disposal trickling filters have been under development for several years. After the vacuum-formed sheet packing of saran is assembled, it is ready to be heat-welded together in a machine especially designed for this purpose. The welded packing is ready to be hoisted into place in the waste disposal tower. Another type of plastic tower packing designed primarily for cooling is injection-molded linear polyethylene grid. The grid is then assembled into a forced-draft cooling unit. One chemical company has under development a tower packing based on coiled sections of polyethylene. Numbers of these packing units fit together yet leave large void spaces.

Safety cannot be overlooked in any chemical plant. Protection helmet shells are made from reinforced phenolic, polyester, or acrylonitrile butadiene styrene plastics. The webbing is nylon and the sweatband is vinyl-coated fabric backed and supported with polyethylene. Safety clothing of various types include vinyl sleeves and aprons, vinyl-coated fabric gloves, and polyester fabric hood and clothing.

In spite of the tremendous present variety of applications for plastics in chemical processing equipment, engineers see much wider usage of these new materials as an exciting challenge.

Furnishings and finishes

Buildings used in the chemical process industries in some respects resemble buildings used in other industries. Offices, laboratories, and other facilities are common to the chemical process industries, the automotive industry, the metallurgical industry, and many others. Thus, furnishings useful in a given type of building will be useful regardless of the industry. In certain areas the problem of chemical corrosion may call for special furnishings or finishes. For example, a typical building in the chemical process industries is a laboratory office area, with melamine walls, lighted through a rigid vinyl ceiling. The furniture and desks are vinyl clad, and it has reinforced polyester doors. The floor of a chemical process office building such as one in a dining room might be based on a vinyl asbestos tile to give the effect of molded cork. In areas where more severe chemical corrosion conditions might be encountered, some ceramic tile could be set with a new epoxy grout, which gives superior strength, chemical resistance, and cleanability over the old cement-type grout. Such epoxy cements could also be used to bond ceramic tile together into large panels up to 4 by 6 ft. for faster installation. The newest thin-bed tile setting development uses methycellulose to control the water absorption and speed the installation.

Figure 8. Silicone paint with aluminum pigment for catalytic cracker.

Modern waiting rooms offer many possibilities for the application of plastics. One particular room is furnished entirely with saran. It includes carpet, drapes, upholstery, and curtains. A conference room in a chemical office building might resemble this all-plastic room but have a polystyrene wall, a melamine table top, vinyl tile and saran carpet flooring, and a ceiling based on polystyrene foam and methyl methacrylate piped lighting. The office itself might be furnished with modern melamine-topped tables and desks, polystyrene wall covering, and a vacuum-formed rigid vinyl map.

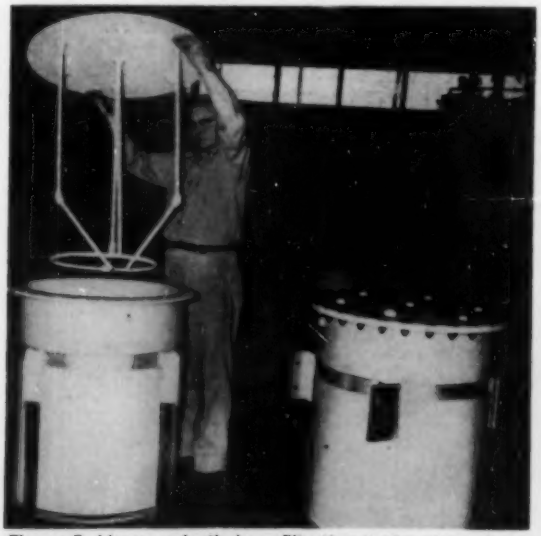

Figure 6. Linear polyethylene filtration tanks shown here in welded steel support cradles.

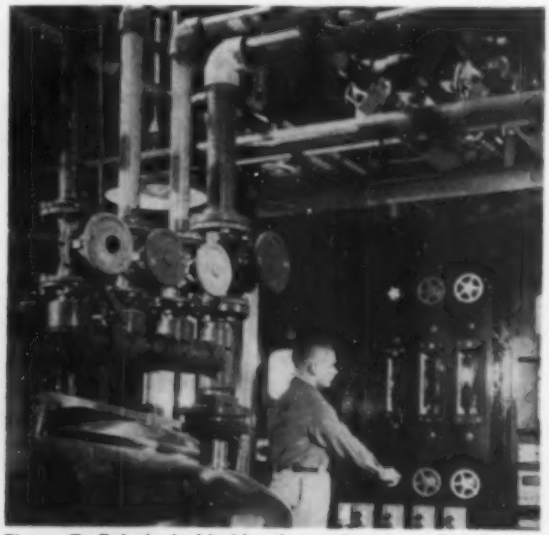

Figure 7. Polyvinyl chloride pipe, valves, and fittings are used in this aluminum hydroxide plant.

. . . a major growing use for plastic materials of construction is in the actual construction of buildings, including air-supported types.

Sprayed-vinyl wall covering on wallboard is a new method of applying a new permanent finish. The completed wall is easily cleaned, chemically resistant, mar resistant, and highly attractive. Ceiling illumination can be accomplished in many ways. One possibility is the use of polyester sheet for a luminescent ceiling as shown here (Figure 9). Or it might be based on fluorescent lighting luminaires.

Another luminair is the suspension type for semi-indirect lighting, giving high reflection with controlled transmission. It is extruded from stabilized polystyrene. Attractive special effects can be obtained by a sandwich-type polyester skylight, using specially shaped plastic cells of phenolic impregnated paper. Plastic materials present innumerable possibilities for furnishing and finishing chemical processing buildings whether for the office building, the library, the laboratory, or the production plant.

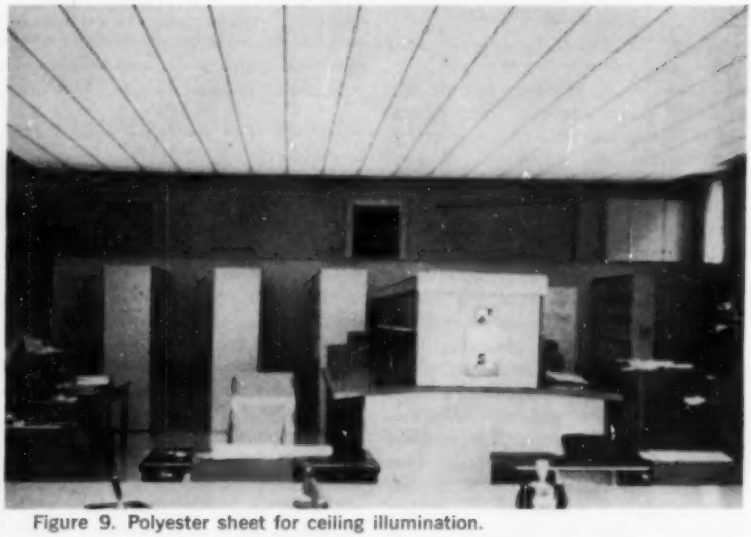

Figure 9. Polyester sheet for ceiling illumination.

Structures

In addition to the main plant, the over-all plant area may well require a variety of other buildings. Among the new possibilities for these buildings are some novel structures based largely on plastic materials. Most people are familiar with the highly publicized Monsanto all-plastic house shown which has been built at Disneyland. During construction, this house, like many chemical plants, was enclosed in a temporary shell of polyethylene film. The structure itself is a sandwich of polyester Fiberglas skins over a polystyrene foam core. Its many other plastic features include the interior finished with plastic walls, floor, counter tops, and furniture, and appliances using plastics in many forms. An indication of the special panel work under development is shown in this laboratory building made up of a variety of sandwich panels with skins of plastic, metal, paper, and wood (Figure 10). The cores are various plastic foams. The panels give good strength, life, and exceptional insulation characteristics. Another approach to office, auditorium, or warehouse-type buildings is based on laminated arches and purlins. The arches are bonded with phenolic and resorcinol plastic glues while they are being formed accurately into shape. One particular building has a span of 123 ft. with arches spaced on 21 ft. centers. Large spans, fire resistance (due to their solid nature), low cost, and appearance favor this approach to building construction.

Another interesting structural development, using the Buckminster Fuller geodesic dome, is frequently covered with a transparent polyester film skin. A modified geodesic-type dome of 55 ft. diam. with all-plastic construction, has been built.

A recent novel approach (Figure 11) to specialized structures is this inflated covering for a swimming pool shown after a heavy snowfall in February, 1958, one year after it was erected. Nearly 60 ft. long and about 24 ft. wide, it has withstood high winds and heavy snow loads. Greenhouse applications for this type of structure are being developed. The sequence of erection of an inflated warehouse under construction is described below as follows. The total weight of the components for a 40 by 80 ft. structure is 600 lb. Six thousand pounds of sand were used to hold the sides down during construction. A total of 40,000 lb. of sand was finally used around the edges to stabilize it against an 80-mile an hour

Figure 11. Air-inflated plastic structure.

wind. The fabric was 16-ounce nylon, vinyl-coated on both sides, and the seams were double lapped and latex coated. The cost of this particular building was about $1.25/sq. ft., and the cost of operating the inflating fan used was only about $1.00/24 hr. A further modification had rigid framed ends joined together with cables. It was assembled on the ground, and lifted into position. As before, air pressure was used to inflate the structure. It is well suited for public assembly. Should a power failure cause collapse of the air-supported structure, it would remain supported by the cables to permit exit of personnel.

In spite of the efforts made by industry to modernize buildings and building techniques, it appears that an ancient civilization using proven methods but new materials may have outdone us. The Canadian Department of Northern Affairs working with the Eskimos has not overlooked the possibilities of cellular foamed plastics. The Eskimos are changing from a nomadic to a sedentary people working on airports, military projects, radar installations, petroleum cracking units, and some chemical process industry plants. The Eskimos need good permanent housing. By simply replacing ice and snow with properly made blocks of plastic foam, a standard 18-ft. diam., 9-ft. high igloo has been developed and is in use in several areas on Baffin Island. The building has withstood 85-mile an hour winds, is drier and healthier than the old-fashioned igloo, and is easy to heat. In tests, one small oil flame has raised the temperature from below freezing to over 100°F. in a matter of only 2 hr. Plastics can improve even the most time-tested basic building structures.

Plastic materials have entered many segments of the chemical process industry since 1940. In doing so, either the method of construction, the operation of the facilities, or its costs have been improved. The present sizable volume of plastic materials now entering the chemical process industries is expected to increase many fold in the next ten years. The future will see growth in established applications, as well as many new and unique developments.

Acknowledgment is made with thanks for the cooperation of 39 industrial companies in the preparation of this article.

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STAINLESS ALLOYS

.... present and future

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Our industrial progress is greatly dependent upon the availability of suitable alloys. The atomic energy, the power, the chemical process, and the transportation industries have under serious consideration process and equipment designs that presently cannot be implemented without improvements in our basic alloys because of the temperatures, pressures, and severe corrosion involved. There are but few industries that could not be improved if better alloys were available. Some of the answers will come only by conducting oriented research leading to brand new alloys; others will come by improving our present alloys, by learning more about them, and by learning how to use them better.

The purpose of this paper is to review the present position of the stainless alloys including the latest developments in new alloys, theory, and practice and to point to the gaps that must be filled in our knowledge if future improvements are to continue.

Stainless steels

It was forty-five years ago that the first corrosion-resisting steel was evolved and the phrase "stainless steel" came into usage. "Stainless Steel" is a generic term covering thirty standard A.I.S.I. grades and a large number of unlisted special grades. Therefore, the term is extremely loose, and in order to properly apply these steels in chemical service, it is necessary to recognize that they differ widely in corrosion resistance and in mechanical, physical, and fabricating properties. While the number of alloys complicates the problem, the wide variety of grades available makes possible the best use of our resources and our industrial effort and an optimum balance of properties and costs.

The stainless steels are ideally suited for many chemical process applications, and it has been said often that the stainless steels are the "work horse" of the chemical process industries. The corrosion uses of stainless steels range from household and architectural through a gamut of chemical, oil refinery, and power plant applications.

Oxidizing conditions are necessary to preserve the passive film that protects the stainless steels from corroding. A chromium content of 12% is sufficient to produce freedom from severe rusting under ordinary atmospheric conditions. As service conditions become more severe, successively higher chromium contents become necessary to promote the formation of passive films, and additions of nickel in amounts of 7 to 35% and Mo in amounts of 2 and 3% are required for better corrosion resistance. The molybdenum-bearing steels are the most resistant of the stainless steels to pit-type corrosion. Other special elements are columbium, titanium, sulfur, phosphorus, and selenium. The first two are added to prevent harmful carbide precipitation

in the chromium-nickel grades, and the last three are added to improve machineability.

Passivity has been defined as a condition of a metal surface which allows it to exhibit corrosion resistance in media where chemical attack would be expected or predicted on the basis of thermodynamic considerations. Passivity is a unique property of several groups of metals and alloys. It is particularly outstanding in the stainless steels and in nickel- cobalt-base alloys containing chromium.

Empirical evidence indicates that passivity is dependent upon the alloy composition, corrosive medium, and prior surface treatments. Recent studies of the nature of the ultrathin passive layers on stainless steels indicate that they are enriched in silicon and depleted in iron and that the enrichment of chromium and nickel is minor. Of particular interest has been the correlation found between weight loss of Type 304 stainless steel and the silicon content of the passive film. Both the weight loss and pitting density were observed to decrease with increasing silicon content in the film. These interesting results should dispel any doubts that improvements in the pit resistance of stainless steels will eventually be forthcoming. However, work still remains to be done to reach a basic understanding of passivity.

Appreciable attention has been focused on the metallurgical and corrosion characteristics of the stainless steels. Several topics fall into this category: a) stress-corrosion cracking and its prevention, b) the effect of 885°F. and sigma-phase precipitation on strength, ductility, and corrosion resistance, c) intergranular corrosion and its prevention, and d) hot-shortness during welding. None of these topics will be discussed in detail here, but they are being mentioned to acquaint the reader with some of the characteristics of these steels which must be given proper attention to obtain optimum service.

Stress-corrosion

Stress-corrosion cracking can occur in all the conventional austenitic stainless steels when they are simultaneously subject to stress and to localized corrosive attack. Most instances of stress-corrosion cracking have been associated with the presence of chlorides in the environment. It should be emphasized that this type of failure is not peculiar to the stainless steels as practically all alloy systems are susceptible to stress-corrosion cracking in certain environments.

From a practical point of view, there are a number of directions which can be taken to alleviate stress-corrosion cracking failures. They are:

1) The most effective method is to minimize the magnitude of the stresses through proper design, fabrication, and assembly, or to change their direction through the use of compressive stresses, since residual tensile stresses cause a majority of the stress-corrosion failures. Solution heat-treatment or stress-relieving after cold-forming and welding are utilized to minimize these stresses. However, if the equipment is large or complicated, the use of heat-treatments is not always practicable. In fact, they may do more harm than good because of the formation of new stress systems during cooling. The only real solution here is to utilize higher alloy materials which show freedom from this type of attack in chloride solutions.

2) Concentrations of chloride should be kept as low as possible and temperatures should not be allowed to rise unduly.

3) The use of anodic inhibitors such as chromates and phosphates which minimize localized attack may be effective but their use, however, is not recommended by all corrosion experts for the reason that such inhibitors are dangerous and may accelerate attack.

4) Cathodic protection appears to be one of the most promising methods of controlling stress-corrosion cracking. This procedure has practical limitations but, since stress corrosion usually occurs in a limited area, it would appear that local cathodic protection could be utilized effectively.

Although many of the features of stress-corrosion cracking have been described, not too much has been done to determine the cause of this type of failure. Some think it is a completely electrochemical mechanism. Others believe the problem more complex than simple electrochemical corrosion and suggest that, in addition, hydrogen plays an important role. Then, there is a matter of crack propagation. Is it due solely to the electrochemical action, or is it mechanical? Answers to these questions are needed to better understand how to prevent this type of failure in austenitic stainless steels.

The cracking of hardenable stainless steels in acid solutions is more frequently due to hydrogen embrittlement than to stress-corrosion. Presumably, the martensite traps hydrogen within its lattice more easily than ferrite or austenite. The susceptibility of these steels to hydrogen embrittlement can be eliminated by tempering at temperatures between 150 and 250°C. Tempering of these steels between 450 and 650°C. should be avoided as the precipitation of carbides in this temperature range imparts susceptibility to stress-corrosion.

Sigma-and-chi-phase precipitation

Stainless steels may lose their ductility under certain conditions of exposure to elevated temperatures due to formation of sigma or chi phase.

The corrosion failures that can be attributed to the presence of these precipitates are practically nil, and they have been observed only in severely corrosive laboratory test conditions. Although it has been difficult to evaluate the individual effects of embrittling phases and carbide precipitation, laboratory studies indicate that the time of holding and distribution of the embrittling phase are very important. The mere presence of embrittling phase does not necessarily impair corrosion resistance of steel.

Chi phase is a very hard, brittle phase that has only been identified in steels containing in excess of 2.5% molybdenum. It co-exists with sigma and can only be identified by X-ray diffraction tests. Its effects on properties are believed the same as sigma.

Intergranular corrosion

The intergranular corrosion susceptibility that the older conventional chromium-nickel steels exhibit after exposure to temperature in the range of 800 to 1700°F. can be eliminated by suitable heat-treatment at temperatures above 1800°F., but in most structures, heat-treatment subsequent to welding is not practical. The precipitation of chromium carbide can be eliminated without the use of heat-treatment either by reducing the carbon below 0.035% or by the addition of titanium or columbium to tie-up the carbon as a stable carbide. The low carbon and stabilized steels may be used for welding without fear of intergranular corrosion developing in subsequent service.

Two extra-low-carbon grades of wrought stainless steel are recognized by the A.I.S.I. and have been developed to minimize intergranular corrosion. One is an 18-8 steel (Type 304L) and the other is an 18-8 type containing molybdenum (316L). The high-alloy foundry industry regularly produces two similar grades designated CF-4 and CF-4M. The casting grades given do not conform exactly with the analysis of the wrought grades due to the special metallurgical and foundry problems associated with

the casting of high-alloy materials. Generally speaking, the extra-low-carbon grades are fabricated and heat-treated in the same manner as the higher carbon steels; however, they are somewhat weaker than the higher carbon steels at both room temperature and at elevated temperatures.

The austenitic stainless steels are generally welded without difficulty; however, cracking tendencies have developed in the welding of heavy sections. The cracking has occurred in both the fusion zone and in the parent metal. This difficulty has been observed primarily with the Type 347 steel due to its widespread use in welded equipment.

An intensive amount of investigative work has been performed on the weld-cracking problem in Type 347 steel; and, although certain aspects are still controversial, considerable progress has been made. Presently, four procedures are being followed to overcome the cracking: a) control of chemical composition of the weld deposit so that there is more than 5% free ferrite in the weld metal; b) control of heating and cooling rates during heat-treatment; c) solution heat-treatment of welds; and d) utilization of a 16% Cr-8% Ni-2% Mo weld metal composition which has superior hot-ductility characteristics at elevated temperatures.

Numerous tests have shown the effectiveness of utilizing a partially ferritic weld deposit to eliminate fissuring. This practice is well established in American industry, and there are several controlled, low-ferrite 19-9 columbium electrodes now available. The most recent electrode development based on this practice is the 16% Cr-8% Ni-2% Mo steel which matches the properties of Type 347 steel with the exception of resistance to intergranular corrosion.

The High Alloys Committee of the Welding Research Council has been investigating, with some success, the possibility of developing a fully austenitic Type 347 steel weld deposit resistant to cracking for the Atomic Energy Commission. Fully austenitic deposits are desirable for certain applications since they are superior in creep strength to those containing ferrite and are more resistant to sigma-phase embrittlement. The results so far indicate that the cracking tendency of fully austenitic Type 347 steel weld metal can be minimized by judicious control of chemistry.

That significant progress is being made in reducing the incidence of weld metal cracking in Type 347 steel is attested by a number of reports in the literature. None of the steam-piping welds made with low-ferrite 347 electrodes and subjected to 1925°F. post-heat-treatment have been found to crack after four years of service. A further continuation of this record would indicate that welded joints in the austenitic steels now possess reliabilities equal to those of the ferritic steels.

Before digressing into the subject of new stainless steels, it should be pointed out in summary of the discussion of the metallurgical characteristics of the stainless steel that much experience has been gained in dealing with the problems which have arisen in the past. With proper attention to certain details, all of them can be avoided or controlled since technical answers are largely available.

New stainless steels

High-manganese stainless steels. During the last few years, two high-manganese steels, designated Types 201 and 202, have been formally adopted by the A.I.S.I. to alleviate shortages of nickel. The compositions of these steels are listed in Table 1.

These steels are similar to Types 301 and 302, respectively in their response to cold-working and in their rate of work-hardening, but they are somewhat stiffer. The greater stiffness is due to the presence of 0.15% nitrogen which raises both the room-temperature strength and the elevated-temperature strength. Available data indicate that the weldability of the 200 steels is excellent.

Type 201 steel has shown no significant corrosion in a number of industrial atmospheres, and it is usable in any corrosion application in which Type 301 steel is applicable. Type 202 steel, while somewhat less resistant to acid corrosion than Type 304 steel, due to its lower nickel content, is capable of resisting a wide variety of mildly corrosive chemicals. The relative corrosion resistance of these steels in laboratory tests and in regular production equipment under chemical plant operating conditions is shown in Table 2. No significant differences in stress-corrosion resistance or galvanic properties have been noted between the Types 202 and 304 steels, however, its resistance to pitting is somewhat lower.

Several virtually nickel-free stainless steels have been developed that are based upon the austenite-forming power of nitrogen. Two of these are "Tenelon" and "Century." The yield strength of these steels in the annealed condition is nearly double that of the Type 301 steel with similar ductility. Their stress-rupture properties are approximately equal to those of the 18-8 molybdenum steels. These steels are in the development stage and their fields of use are still being investigated.

Several high-carbon, high-nitrogen, austenitic chromium-manganese steels have also been developed principally for special applications at elevated temperatures. Composition includes: CMN—Cr-25/0; Mn-12.0; C-0.65; N-0.45; G-192—Cr-21.25-22.75; Mn-8.0-9-0; C-0.55-0.65; N-0.30-0.40.

These steels fulfill the need for a strong, hard, erosion- and oxidation-resistant material for service at temperatures of 900 to 1600°F. They are more resistant to wear, erosion, galling, and seizing than other austentic materials, but because of their susceptibility to intergranular corrosion, these steels have only limited corrosion applications.

Precipitation-hardening steels. During the past few years, several precipitation-hardening stainless steels have been developed which can be hardened by relatively simple heat-treatments. These steels develop strengths which can only be produced in the standard stainless steels by severe cold-working. Grades include: martensitic types: stainless W, 17-4PH, Am 350 and 355 and FV520; semiaustenitic types: 17-7 PH, 15-7 Mo; cast semiaustenitic types: CD-4M Cu, V2 B.; austenitic types 17-10P, HNM, 22-4-9, 22-12.

The precipitation-hardenable stainless steels can be grouped into two basic classes: 1) those which are hardened by precipitation from a martensitic matrix, and 2) those which are hardened by precipitation from an austenitic matrix.

The advantages of the martensitic steels follow:

1) Higher tensile and compressive yield strengths than the standard hardenable steels such as

Table 1. Austenitic Chromium-Nickel Manganese Steels

	Composition, %					
Type	Cr	Ni	Mn	Si	C	N
201	16.0-18.0	3.5-5.5	5.5-7.5	1.0 max.	0.15 max.	0.25 max.
202	17.0-19.0	4.0-6.0	7.5-10.0	1.0 max.	0.15 max.	0.25 max.

Types 410 and 416.

2) Excellent mechanical properties up to 900°F.
3) Corrosion resistance superior to the standard hardenable grades.
4) High fatigue endurance limit.
5) Resistance to galling and seizing.
6) Short-time heat-treatment eliminates scaling.
7) Good resistance to stress-corrosion cracking.
8) Good fabricating properties.

Some of the precipitation-hardening steels retain their austenitic matrix after solution heat treatment. These steels are more readily formable than the steels which develop a martensitic structure on cooling from the solution heat-treating temperature.

The precipitation-hardenable stainless steels are not outstanding in resistance to corrosion; but, in general, they perform better than the hardenable 400 series of steels. If corrosion resistance is a critical factor, the applicability of these steels should be carefully evaluated by suitable field tests.

Certain austenitic precipitation-hardening alloys are of relatively recent origin and are still under development. The 17-10P alloy was designed for use in applications requiring high strength and low magnetic permeability. The HMN alloy has been suggested for gas turbine, steam turbine, and cracking still uses. Both steels are difficult to weld. The V2B alloy has corrosion resistance approaching Type 316 steel combined with good strength and gall resistance. Alloy CD-4MCu is a high-strength cast alloy having corrosion resistance comparable to 18-8 steel that can develop a yield strength of 100,000 lb./sq. in. It gains its strength from the precipitation of sigma phase. Being of recent origin, its corrosion-resistance characteristics have not been fully explored.

Special high-alloy stainless steels. A number of special high-alloy stainless steels have been developed in which, in some cases, the nickel content exceeds the chromium content and in which molybdenum, copper, and silicon are added in significant amounts. These alloys are used for handling sulfuric acid solutions at higher temperatures than can be handled by the standard types of stainless steels. Because they are more resistant to reducing conditions than the standard stainless steels, these alloys find considerable use with phosphoric, hydrofluoric, and sulfurous acid solution and salts, and with oxidizing media such as nitric and chromic acids and cupric, ferric, and mercuric salts. They can handle a

Table 2—Comparative Corrosion Data—Type 202 vs. Type 300 Stainless Steels

Environment	Exposure			Corrosion Rate i.p.y.					
				Chromium–Nickel			Chromium–Nickel–Manganese		
	Phase	Approx. Temp °C	Hours	Type 304	Type 316	Type 347	R-975	R-976	GM-83
Alkyl amines, mixed	liquid	100	744	nil	nil	nil	nil	nil	
	vapor	100	744	nil	nil	nil	nil	nil	
Dimethoxybutane, crude	liquid	130	48	0.0002	0.0002		0.0003	nil	
Distillation, alkyl phenol	liquid	205	1080	0.0008					0.0016**
	vapor	205	1080	0.0002	nil				0.0002**
Distillation, crude acetic acid–acetic anhydride	liquid	117	2736	0.0711[3]	0.0134	0.0843			0.1041**
	vapor	110	2736	0.0485[3]	0.0174	0.0733			0.0675**
Distillation, crude alkyl aldehyde	liquid	130	480	0.0142[1]	0.0045[1]				0.0163[1]**
	vapor	120	480	0.0917[2]	0.0043[2]				0.0647**
Distillation, high boiling ketone	liquid	140	163	0.0134	0.0020		0.0361	0.0279	
	vapor	130	208	0.0026	0.0003		0.0090	0.0045	
Distillation, higher organic anhydride	liquid	210	156	0.0474[1]	0.0072[1]		0.0226[2]	0.0257[2]	0.0304[1]*
	vapor	180	322	0.0071	0.0045		0.0002	nil	
Distillation of "organo"–nitrile in presence of water	liquid	105	3624	nil	nil		nil	nil	nil
Environment, hydrogen sulfide at high temperature									
A. Middle oil distillation system–feed tray	liquid	250 to	1296	0.0453[1]	0.0263[2]				0.0155[1]
B. Middle oil distillation system–tray No. 2	liquid	340	1016	<0.0001	<0.0001				<0.0001
C. Middle oil distillation system–vent	vapor	↓	1224	nil		nil			nil**
D. Light oil distillation system–top of col.	liq.-vap.	150-360	2415	nil	nil		nil	nil	
E. Heavy oil distillation system–top of col.	liq.-vap.	300-340	2415	nil-0.0005	nil		nil	0.0007	
F. Dewatering still kettle	liquid	120	2415	nil	nil		nil	nil	
G. Product Storage Tank –vapor space	vapor	ambient	1224	nil		nil			nil**
Evaporation, alkyl sulfate									
No. 1 evaporator	vapor	50	192	0.0083			0.0162	0.0179	
No. 2 evaporator	vapor	70	192	0.0001			0.0001	0.0001	

**GM-82 Alloy [1]Average of four exposures [2]Average of two exposures [3]Type 304L

variety of neutral and alkaline chloride solutions because of their resistance to pitting, and have found use in pumping sea water. Designations include Carpenter 20, 17-14 Cu Mo etc.

Ferritic high-temperature steels. During the past few years, the increasing needs of the aircraft industry for ferritic materials to withstand high stress with temperatures up to and including 1100°F. have resulted in the appearance of a series of modified martensitic stainless steels. They possess a good combination of oxidation resistance and strength with a low thermal coefficient of expansion and low strategic alloy content.

These steels are used in the aircraft industry for such parts as compressor blades and rotor disks where their combination of oxidation resistance and strength are particularly important. These steels are not noted for their resistance to chemical corrosion. Grades include Rex 448, H46, 422, 422M, 12MOV and 418 special.

High alloys

Nickel-chromium and nickel-chromium-iron alloys. Nickel-chromium alloys containing 60 to 80% Ni are superior to the stainless steels in reducing and in strong alkaline conditions, yet they resist satisfactorily many oxidizing solutions. The 14.5% Cr-6.5% iron alloy (Inconel) has been utilized to the greatest extent for corrosion-resisting purposes and has shown good resistance to many types of environments involving both reducing and oxidizing conditions. Inconel is considerably more resistant than the stainless steels to stress-corrosion cracking in boiling magnesium chloride solutions and has been recommended for this type of service. During the past several years, more attention has been directed toward improving the high-temperature and oxidation-resistance properties of these alloys than their corrosion resistance.

It has long been known that the nickel - chromium and nickel - chromium-iron alloys are useful for high-temperature purposes because of their resistance to oxidation, carburization, nitriding, and molten salts. The "80-20" type alloys are extensively used for electrical resistance heating and aircraft valves, and the "60-15" and the "35-15" cast alloys are used for furnace parts. Inconel and Nimonic sheet alloys have been satisfactory alloys for flame tubes, combustion liners, and exhaust systems. The most recent addition to this series is Alloy 805, containing approximately 32% Cr and 45% Ni, which has demonstrated

Environment	Exposure			Corrosion Rate i.p.y.					
				Chromium–Nickel			Chromium–Nickel–Manganese		
	Phase	Approx. Temp °C	Hours	Type 304	Type 316	Type 347	R-975	R-976	GM-83
No. 2 evaporator	liquid	50	192	0.0086			0.0183	0.0001	
No. 2 evaporator	liquid	70	192	0.0001			0.0002	0.0001	
Oxidation, aldehyde to organic acid	liquid	60	161	0.0007	nil				0.0002
	liquid	60	161	0.0003	nil				0.0029
Preparation of agricultural chemical	liquid		528		nil				0.2728
Preparation, unsaturated organic acid	liquid		696	nil	nil				nil**
Purge, high-boiling ether with hydrogen chloride	liquid	100	23	0.0050	0.0046				0.0062
Reaction, esterification with H_2SO_4 present	liquid	90	24		0.0329		0.9970	0.8960	
	liquid	90	24		0.0332		0.9890	0.1880	
Reaction, esters using unsaturated organic acid with H_2SO_4	liquid		154	0.0013	nil	0.0016	0.0002	nil	nil
Reaction, mixed esters	liquid	120	750	nil		nil			nil
	liquid	120	750	nil		nil			nil
Reaction, hydrocarbon–carbon dioxide reaction	liquid	150	312	nil	nil		nil	nil	
	vapor	125	312	nil	nil		nil	nil	
	liquid	140	336	nil	nil		nil	nil	
	vapor	100	336	nil	nil		nil	nil	
Reaction, organic amino sulfate	liquid	90	81	0.0071	0.0126		0.0168	0.0240	
	liquid	90	81	0.0231	0.0137		0.0190	0.0423	
Storage, agricultural chemical water solution	liquid	room	312	nil					nil
Storage, high boiling ether-hydrogen chloride solution (dry)	liquid	room	312	0.0064	0.0017				0.0048
Storage, high boiling ether-hydrogen chloride solution (wet)	liquid	room	216	0.0068	0.0035				0.0030
Storage, insecticide water solution	liquid	room	113	nil			0.0001	0.0001	
Storage, organic fluoride	liquid	0	1600	0.0006	0.0003		0.0010	0.0009	
System, distillation acetic acid acetic anhydride	liquid	105	17685 (2 yrs.)	0.0040*	0.0024	0.0043			0.0025**

Note: Chemical analyses of 300 series (304, 316 and 347) met all the special requirements of the PVM Specifications.

considerable resistance to carburization and to sulfurization at elevated temperatures.

A host of new alloys based on the nickel-chromium system has been developed to meet the special requirements of gas turbine engines. All of them depend on the precipitation-hardening characteristics imparted by titanium and aluminum for their strength. These alloys are difficult to produce by air-melting and production by vacuum-melting is receiving widespread consideration. So far, none of them has been utilized for resisting chemical corrosives. Grades include: Inconels W, X, 700, 702, 713, and cast; Nimonics 80A, 90, 95, and 100; R-235; Waspaloy; Udimet 500; and M252 for the nickel-chromium alloys. For the nickel-chromium-iron alloys grades include: A286; M308; Discaloy 24; Incoloy T and 901.

Nickel-chromium-molybdenum-iron alloys. Typical alloys of this type are Illium R and G and LaBour R-55 alloy. The principal application of these alloys is in handling mixed acid solutions at elevated temperatures. Two new alloys, Ni-O-Nel and Hastelloy alloy F, have recently been developed which fall into this category. The high iron content of these alloys makes them somewhat lower cost materials than the earlier alloys of this group.

Ni-O-Nel is available in all wrought mill forms and is capable of resisting many reducing acid solutions and a variety of oxidizing-type solutions too aggressive for the stainless steels.

Hastelloy alloy F has been found to be an excellent material for use in sulfite digesters. Some difficulty from intergranular cracking in the parent metal adjacent to welds has been experienced in this environment which has been overcome by lowering carbon to about 0.02% maximum by vacuum-melting. The alloy is exceptionally resistant to stress-corrosion cracking and magnesium-chloride solutions and is more resistant to pitting in sea water and to reducing conditions than any of the stainless steels; however, the alloy is susceptible to concentration cell corrosion in chloride solutions and cognizance of this type of corrosion should be taken into account when applying this alloy to chloride-containing environments.

Nickel-molybdenum and nickel-molybdenum-chromium alloys. Representative alloys in this group are Hastelloy alloys B and C and Chloromet 2 and 3.

The Ni-26 to 30% Mo alloy was developed for handling hot hydrochloric acid, wet hydrogen chloride, and hot sulfuric acid. It is most resistant under reducing conditions and is not suitable for use with oxidizing salts. The nickel-molybdenum alloys resemble the metals, such as copper and gold, which fall below hydrogen in the electromotive series. Therefore, they fall outside the category of alloys which depend upon passive oxide films for resisting corrosion such as the chromium-bearing stainless alloys.

The addition of chromium to nickel-molybdenum alloys imparts to them a high degree of resistance to oxidizing agents such as nitric acid, ferric and cupric chloride, and aqueous chlorine. These alloys are essentially inert to sea water and retain a mirror polish indefinitely when exposed to salt-air atmospheres. In reducing media, the alloy assumes the role of a noble metal although it is less capable of doing so than the nickel-molybdenum alloy.

In general, these alloys are amenable to all types of welding. Cracking during fusion welding has been rarely encountered in the weld bead, but it has been observed in the parent metal adjacent and transverse to the weld bead. Crimping can alleviate cracking due to high restraining stresses, and this technique has been used in the lining of large vessels with thin gauge sheet. Porosity can be a problem in inert gas, shielded arc-welding if the shielding gas is dispersed or the nitrogen content of the gas is too high.

These alloys are used frequently in the as-welded condition; however, in very aggressive environments, intergranular attack of the heat-affected zone or preferential attack of the weld may occur. Prior testing of the as-welded condition is therefore desirable to ensure satisfactory corrosion resistance.

Optimum corrosion resistance is developed after welding by solution heat-treating at temperatures between 2100 and 2250°F. followed by a relatively fast cool in air or water. Care must be taken not to overheat these alloys since they have a low solidus temperature, and it is important to maintain good temperature control since these alloys have only a narrow range in which to gain the degree of solution required for optimum properties and corrosion resistance. Since rapid cooling after solution heat-treating may produce serious warpage and residual stresses, full consideration must be given to these difficulties when selecting these alloys for complicated equipment.

To reduce costs, these alloys are frequently used in the form of cladding. The problem of cladding these strong materials to weaker materials has been a difficult one, but recent developments in roll cladding and in brazing of sandwiches look very promising.

Future outlook

Without question, the future outlook for stainless alloys is bright, although admittedly, the timetable of future developments is not clear at the present time. Many of the irritating problems of today which defy solution with existing knowledge are only temporary delays in our forward progress. It is probable that the rapid rate of development of new alloys that has occurred during the past fifty years will decrease somewhat, but it is expected that it will be restored again when the results of new basic research are available. For example, it has not been too long since the solid-state physicist began to delve into the effects of controlled impurities on electrical behavior of metals, yet phenomenal progress has been made, and today we enjoy the results of this work in the form of improved electronic equipment. While most of the benefits of this work have accrued to the electronics field, it is fully anticipated that fundamental studies will benefit the stainless alloys since we have hardly scratched the frontier of scientific knowledge which lies ahead. We are thinking particularly of improvements in stability at elevated temperatures, pit- and stress-corrosion resistance, oxidation and general corrosion resistance, hot- and cold-ductility, strength at elevated temperature, etc., that can result from basic studies. Although today we depend upon empirical approaches, from the progress already made, it is not unreasonable to expect that tomorrow's alloys will be designed for specific uses on a well understood precalculated basis. That a good start has already been made in this direction is exemplified by the encouraging improvements in resistance of the 18-8 steels to pit-type corrosion which are indicated by recent basic surface-film studies. Theoretical analyses of anode corrosion behavior conducted in the Electro Metallurgical Company's laboratory also indicate that striking improvements in the general corrosion resistance of some of the stainless alloys will be made. There are undoubtedly other examples of research equally dramatic existing in other laboratories.

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Titanium and Zirconium in chemical plant applications

Both are metals assuming increased importance as construction materials for corrosive applications. Equipment fabrication techniques are progressing.

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THERE IS NO DOUBT that this is the age of high performance materials. New requirements for materials during the past decade have spurred the development of unconventional metals and alloys as never before. Properties such as neutron-capture-cross-section, strength-weight ratio, specific impulse, and reaction to radiation have assumed tremendous importance. Many materials unearthed in response to these demands are highly specialized, having a narrow sphere of use. Two marked exceptions to this situation are titanium and zirconium. For while titanium received its stimulus in the field of jet propulsion, and zirconium in atomic reactor construction, these applications, in contrast to an expected pattern, have proven a starting point for much broader fields of use.

The chemical process industries, with chemical manufacturing in the forefront, are among the areas of both immediate and future utilization of titanium and zirconium. It is the purpose of this paper to report on the progress already made in process applications, and to predict what we may expect to see during the next few years.

Titanium

Most present process applications of titanium are based on corrosion resistance. Other properties that have also accounted for some use include resistance to cavitation, low-thermal expansion, resistance to sticking and "wetting," and the combination of high-strength-medium modulus.

Corrosion resistance

The corrosion resistance of titanium is in some respects similar to that of stainless steel (*1*). Titanium forms a thin, tough protective film when exposed to air or most other oxidizing media. Because this film is easily maintained, particularly under oxidizing conditions, titanium displays extraordinary resistance to natural environments and to many strongly corrosive oxidizing chemicals and solutions (*2*).

It is readily attacked by hydrochloric and sulfuric acids at even moderate concentrations and temperatures. Despite this, a considerable number of applications have been made in hydrochloric and sulfuric acid service. This is possible because the protective film can be preserved by the presence of oxidizing agents (e.g., nitric acid, chromic acid, cupric, ferric, stannic ions) in these acids (*3*). The excellent resistance of titanium to aqua regia is a notable example of attack inhibited by an oxidizing agent.

An outstanding feature of titanium with respect to corrosion is its resistance to inorganic chlorides, wet chlorine, and the hypochlorites. Furthermore, it does not appear susceptible, in such environments, to stress corrosion cracking or to intergranular attack of the heat-affected zone of welds. The only reagent found to promote stress corrosion cracking in titanium is red fuming nitric acid (*4*). Table 1 summarizes the corrosion behavior of the metal.

Applications

Unalloyed titanium rather than titanium-base alloys has proven adequate for most process applications. Its strength levels range from 40-70,000 minimum yield, sufficient for chemical equipment. It is readily welded and fabricated, and more is known of its corrosion behavior.

At this moment, titanium mill products are priced at $8 to $14.00/lb. When titanium's lower density is considered, together with its fabrication expense (which is little more than for stainless), a finished unit in titanium is only two to four times more expensive than one in stainless.

The metal is finding use in cases where savings through longer service life outweigh the higher initial investment. Titanium is outlasting other materials by factors ranging from 5 to 25. In terms of reduced downtime, maintenance, and lost product, economic justification is often striking.

Dupont Experience. Nitric acid operations represent a growing area of use. In one Dupont plant a process involving 60% nitric acid at 480° F. and 300 lb./sq. in. pressure limited the service life of stainless steel condensers to six months. Titanium has extended the life of the units to an expected ten years. When the costs of the labor associated with each six-

Titanium and Zirconium

continued

month replacement are combined with the actual equipment expenses over the ten-year period, the total savings realized through titanium amount to an estimated $162,000.

Several other firms have experienced similar results in nitric acid with titanium. Units presently installed include fabricated piping assemblies in diameters up to four inches, heat exchangers, coils, agitators, and a variety of accessories such as thermowells, diptubes, nozzles, fasteners, and valve trim.

The Wyandotte Chemicals Corporation has reported several highly successful applications, including a sodium hypochlorite heat exchanger; a pump impeller and shaft in an organic chloride-hydrochloric acid-wet chlorine solution; and packing supports in a chlorine-caustic tower.

A cost study at Wyandotte revealed an annual cost of $39 for the titanium pump impeller compared to $420 for a nickel-chrome-molybdenum impeller *(5)*.

Because of a comparatively higher heat transfer rate, titanium has been reported as an effective improvement over glass and other nonmetallics in sodium hypochlorite cooling installations.

Steam jet diffusers, handling high pressure steam and dilute hydrochloric acid, represent probably the first industrial use of titanium. In this case, the best previous material lasted six and one-half months. Titanium units show no corrosion or erosion effects after nearly five years' service.

Ore beneficiation accounts for the largest and most extensive current process applications.

Freeport Sulphur Example. The Freeport Sulphur Company's selection of titanium for nickel-cobalt ore processing equipment involves kettle-type heat exchangers, piping, and other apparatus. Titanium turbine impellers and agitators have lasted four years at a Calera Mining installation, where alloy steels and nickel alloys failed in a matter of hours. The environment is sulfuric acid and a cobalt-iron-arsenic slurry at temperatures exceeding 400° F. *(6)*.

Although many equipment applications are by no means confined to any one industry, Table A lists these units to point out the considerable scope of present titanium service.

Titanium equipment is coming down in cost, not only because of decreased mill product prices but also because many fabricators have gained experience and confidence in the metal.

Future

For the next several years titanium is bound to make a continuing further penetration into present areas of use. It is a demonstrated fact that one titanium application at a plant quickly mushrooms into others. Commercial availability of castings, which is now a reality, has opened an entire range of pumps, valves, and similar apparatus to titanium specification. Another step which will lead to increased industrial use concerns code-approval of titanium for unfired pressure vessels, which is now in progress.

Titanium-clad products, feasible in tanks and vessels, now enable several equipment designs heretofore impracticable.

Illustrative titanium applications

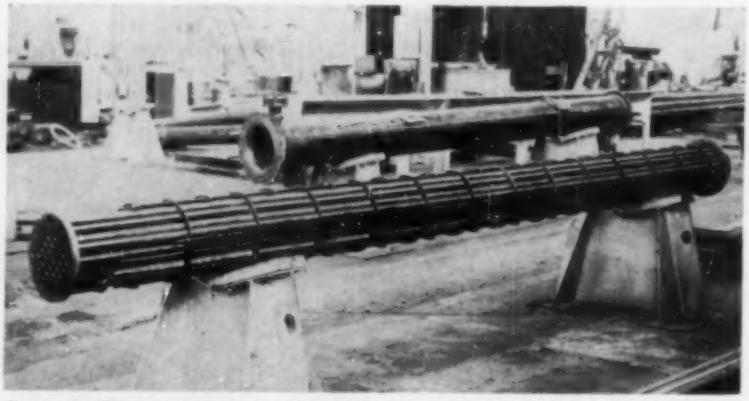

Figure 1. This heat exchanger is used to cool a 15% solution of sodium hypochlorite. Resistance of the metal to the hypochlorites and wet chlorine is excellent and is resulting in a rapidly growing field of use.

Figure 2. Fabricated pipe section is 4-in. schedule 10 welded titanium.

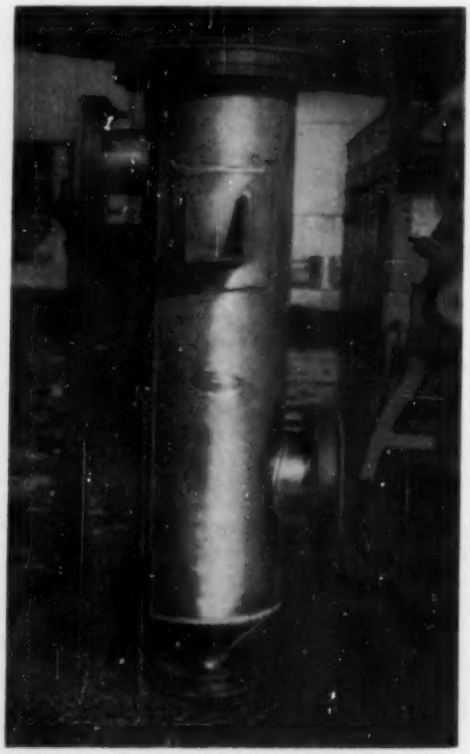

Figure 3. The jet after-condenser in an environment of nitric acid, organic acids, and raw brackish water.

tical. Beyond this, only the imagination limits the development of new uses. A vast potential, for example, exists in marine and salt water equipment.

Several food-processing applications already appear very close. The complete resistance of titanium in a wide range of foods and juices, plus a reported immunity to taste or color transfer, indicates not only commercial but also household use.

Photographic film processing; petroleum production and refining; molten sulfur operations—initial evaluation in these fields indicate widespread potential.

Corrosion-resistant titanium-base alloys having improved resistance to reducing environments are a definite possibility.

Assuming suitable properties, it may be said of any material that new uses depend greatly on price, and development effort. Titanium is no exception to this pattern. Additional applications have so far followed every price decrease.

To be sure, time and work are required in copious quantities but this much is certain: titanium will some day be as widely used in process service as stainless steel.

Zirconium

Although zirconium application in chemical plants is still in its infancy, interest in the field is fast mounting.

During recent years, zirconium production capacity has grown to its thriving present level, which exceeds five million pounds annually. Nuclear applications of the metal have accounted for this rise. Commercial grade (nonnuclear) zirconium, containing up to 2.5% hafnium, has been employed for most industrial and chemical process applications. Conventional mill forms are available. Shops experienced in titanium construction should have little difficulty in fabricating zirconium, since the metals behave similarly in forming and welding *(8)*.

Corrosion. Outstanding resistance is exhibited by zirconium to alkalis in all concentrations up to the boiling point. It appears inert to fused caustic *(1)*.

Hydrochloric acid applications are well suited to the metal, with generally exceptional resistance displayed at temperatures up to 210°F. *(1)*.

Excepting ferric and cupric chloride, behavior to inorganic chloride environments is excellent, as is also the case with nitric acid, and chlorinated organic compounds *(1)*. A summary of corrosion behavior is found in Table 2.

Applications – Bureau of Mines Tests. Zirconium metal has been employed to excellent advantage in trial applications conducted by the Bureau of Mines. These uses were classified as experimental, production, and laboratory and included the following examples: *(9)*:

1. An experimental pulse column which employed zirconium plates in both alternating and joint solutions of (1) 1 to 3 *N* hydrochloric acid with trace amounts of ferric chloride and thiocyanic acid, and (2) 5 *N* sulfuric acid. A ketone solvent present in both solutions prohibited the use of plastics in the reaction. No visible evidence of corrosion was observed after six months' operation *(10)*.

2. A zirconium-lined tank replaced a glass-lined unit in an abrasive slurry containing hydrochloric acid. No evidence of corrosion was noted after three months *(11)*.

3. Zirconium steam-jet exhausters handled hydrochloric acid and zirconium chloride fumes, giving trouble-free performance for over a year. Type 316 stainless impellers in this service required overhaul at ten-day intervals *(12)*.

4. Components such as thermowells, exhaust fans, fittings, proportioning pump parts, and spray nozzles all showed excellent advantage in highly corrosive acidic and chloride environments *(13)*.

5. Zirconium laboratory crucibles used for caustic fusions have outstanding utility in analytical laboratories, where platinum and other wares corrode and fail *(14)*.

A large number of chemical firms are presently testing zirconium

TABLE 1. Commercially Pure Titanium

Examples of uncorrosive environments	Examples of corrosive environments
Nitric acid	Red fuming nitric acid*
Acetic acid	Hydrochloric acid (over 3%)
Chromic acid	Sulfuric acid (over 4%)
Wet chlorine (minimum 0.1% moisture)	Hot concentrated aluminum chloride
Hypochlorites	Trichloracetic acid
Sea water	Hydrofluoric acid
Chlorine dioxide	Fluoride solutions
Food products	Oxalic acid
Aqua regia	Dry chlorine
Chlorinated hydrocarbons	Fused salts
Ferric, zinc, magnesium chlorides, etc.	Unaerated formic acid
Dilute hydrochloric acid (to 3%)	
Dilute sulfuric acid (to 4%)	

*Tests in red fuming nitric acid should be approached with caution in view of the possibility of violent reaction.

a. Generally good in oxidizing environments
b. Generally fair to poor in strong reducing environments
(In many cases, inhibitors can be added or are already present which improve the resistance of titanium in reducing solutions.)

Table 2. Commercial Grade Zirconium

Generally good corrosion resistance		Generally poor corrosion resistance
Hydrochloric acid		Aqua regia
Sodium hydroxide		Hydrofluoric acid
Nitric acid		Fluorides
Inorganic chlorides	except	Ferric and cupric chlorides
Mixed acid	except	Mixed acid containing more than 10% sulfuric acid
Phosphoric acid	except	Phosphoric acid over 75%
Chlorinated hydrocarbons		Wet chlorine
Organic acids		

Table A. Current Titanium Service

Unit	Environment	Industry
1. Jet aftercondenser	Nitric acid-organic acids-brackish water	Chemical
2. Lined mixer	Chlorine dioxide-water	Paper pulp
3. Pumps & nozzles	Ferric chloride	Electronic
4. Jacketed kettles	Pickle liquor, tomato products	Food
5. Filter press plates	Calcium hypochlorite	Chemical
6. Bayonet heaters	Cuprous chloride	Chemical
7. Helical coils	Sulfuric acid-metallic sulfates	Chemical
8. Tanks & agitators	Chromic acid solutions	Electroplating
9. Tubular coolers	Nitric acid-organics	Pharmaceutical
10. Drying trays		Dye

Titanium and Zirconium

continued

samples in a variety of environments. Several have had prototype equipment pieces such as valve trim, tubing assemblies, and impellers fabricated and installed in plant service.

Operations involving the presence of both alkalis and acids, either alternately or at different points in the same equipment are natural points for zirconium application *(7)*.

Titanium and zirconium hold great promise for the future. Titanium chemical plant applications in many instances are already well past the developmental stage, and zirconium is off to a good start.

Each metal has shown a history of constant price decline and it is certainly reasonable to expect further lowering of price. Titanium even now is nearly competitive with several standard corrosion resistant alloys.

It is probable that, of the two metals, titanium will always be the lower priced for reasons of availability, production, and range of use. The metals are complementary in some respects concerning process application, and it is doubtful whether titanium and zirconium would be found competing for the same use.

Titanium will find a much wider ultimate use field than zirconium. Zirconium, however, should secure a firm position as a specialty metal, particularly in hydrochloric acid and alkali-acid environments. In view of the trend towards continuous processing, titanium and zirconium have come to the chemical engineer at an opportune time. Each metal can offer a substantial contribution to the increasing integrity being required of materials and equipment in continuous systems.

Certainly the most encouraging fact about titanium and zirconium is that as more is learned about the metals and their alloy systems, and their areas of application, the horizons broaden. Both metals are here to stay.

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Future Metals

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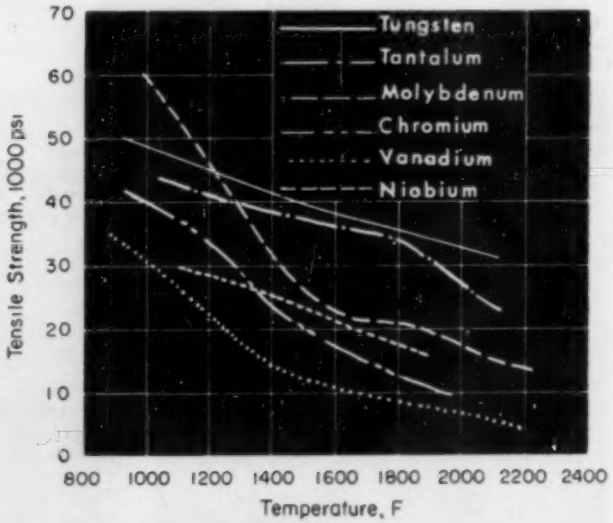

Figure 2. Tensile strengths of the future metals in the 1000 to 2000 °F range. *(10-13)*

The group of metals which appear to have the best potentialities for extending the limits of present-day materials of construction are the Group V and Group VI transition elements. These, together with one element from Group VII, rhenium, are the subject of this paper. Each of these metals, for one reason or another, has been relatively scarce, particularly for usage in chemical engineering applications. However, despite its scarcity, tantalum has found its chief application in the chemical equipment field.

Physical and mechanical properties

In Figure 1, on the facing page, are shown the effects of temperature on the unnotched tensile ductility of the refractory metals. It can be seen that, at the purity level tested, there is an abrupt change in ductility at a critical temperature for each of the Group VI-A metals. Molybdenum has a transition temperature at about room temperature, while chromium and tungsten have ductility transitions considerably above room temperature. The Group V-A metals have much lower transition temperatures, niobium is ductile to below −100°C.

while tantalum is ductile down to at least −195°C. Data are not yet available on low-temperature properties of vanadium, but its similarity to niobium and tantalum would indicate that it, too, would have a low transition temperature. It can be seen, then, that from the low-temperature ductility criterion the Group V-A elements are more promising than the Group VI-A elements.

Unlike other metals, strength of the future metals decreases only slightly with increasing temperature, and it is at temperatures above about 1500°F. that the importance of the strength properties can be seen. In Figure 2 are shown the tensile strengths of the subject metals in the temperature range of 1000 to 2000°F. The strength levels are not much lower in this temperature range than at room temperature. Another important point is the relation of tensile strengh to melting point. It can be seen that the temperature-strengh curves are in the approximate order of increasing melting point of the metal. This can be seen more graphically in Figure 3 where the strength of the metals is plotted vs. homologous temperature. Homologous temperature is the ratio of the absolute test temperature to the absolute melting temperature. The general shapes of these curves show that there is a qualitative relationship of elevated temperature strength to melting point. Also, it appears that the Group VI metals (Cr, Mo, W) have slightly higher strengths in the temperature range of 40 to 60% of their absolute melting points than do the Group V metals (V, Nb, and Ta).

Data illustrative of rupture and creep properties at 1800°F. of the subject metals are given in Table 1 together with their tensile properties at 1800°F. Again it is seen that the higher melting point metals have the better properties.

Corrosion resistance and oxidation

The corrosion resistance of the future metals is generally good in acid media at atmospheric temperatures. A summary of the general corrosion characteristics of these metals is given in Table 2.

In contrast to the good corrosion resistance of these metals, their high-temperature oxidation resistance is generally poor. Only chromium shows good resistance to attack by oxygen at elevated temperatures. However, chromium is attacked by nitrogen at elevated temperatures and must be alloyed to prevent nitrogen reactions. Two of the metals (vanadium and rhenium) form low-melting oxides, and one metal, molybdenum, forms a volatile oxide. Oxidation rates for these metals are extremely high and in the case of molybdenum it has been termed catastrophic oxidation. Tungsten, tantalum, and niobium have high oxidation rates which are linear with respect to time. An illustration of the oxidation rates of Group VIA metals and niobium is shown in Figure 4.

In addition to having high oxidation rate, the Group V-A metals are subject to contamination by oxygen. The solid metals can dissolve a significant amount of oxygen when heated in air or oxygen-bearing atmospheres. The dissolved oxygen hardens and embrittles the metals. The solution of oxygen in these metals is a diffusion controlled process, the depth of contamination being dependent on the time and temperature of exposure. Some results of recent work on niobium (*18*) shown in Figure 5, illustrate the effects of time and temperature on the depth of contamination.

Present applications

Of the Group VA metals, V, Nb, and Ta, only tantalum has been utilized as a structural material in its pure form. Tantalum, because of its excellent corrosion resistance in almost all acids, has found extensive use for acidproof equipment.

Vanadium and niobium have as yet found no application in the chemical industry.

The Group VI-A elements, chromium, molybdenum, and tungsten have rather diverse uses at the present time but have not as yet found application, in their pure form, in chemical processing equipment. In its pure state chromium has not been used as a structural material because of its inherently poor ductility. In all applications involving elevated temperature, molybdenum must be protected from the atmosphere or be used in an inert or reducing atmosphere.

The results of studies to date show that rhenium has many interesting properties which would be appealing for structural applications—high modulus of elasticity, good strength and ductility combinations, high melting point, and good elevated temperature properties. However, the limited potential availability of rhenium has almost dictated that the research be directed toward small-volume uses for the metal.

A look at the future

There appears to be little doubt that one of the most important uses in the future for the heavy refractory metals (tungsten, tantalum, molybdenum, and niobium) will be in applications requiring high strength at very high temperatures. These four metals appear to have the greatest potential for meeting the requirements for materials of construction in high-temperature jet engines, rocket motors, high mach number airframes, and missiles.

It has already been shown that the refractory metals have unsurpassed strength at temperatures of 2000°F. and above, but that the high oxidation rate is the chief problem. The large amount of research conducted on molybdenum has shown that suitable protective coatings are available for preventing the catastrophic oxidation which has plagued the use of

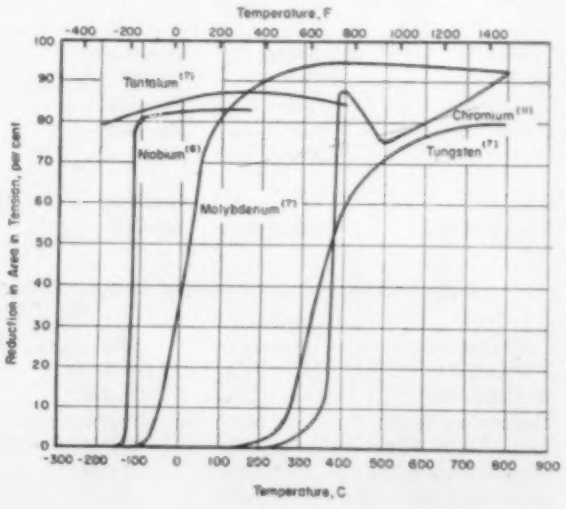

Figure 1. Effect of temperature on the ductility of chromium, molybdenum, niobium, tungsten, and tantalum.

Future Metals

continued

molybdenum in the past. Typical coatings are given in Table 3. One of the most important functions of a protective coating particularly for sustained service at high temperature is to be self-healing in the event of a crack or an imperfection in the coating. Only the clad nickel or nickel-base alloy coatings have the capability of self-healing properties. Nickel in contact with molybdenum will form a nickel molybdate when oxidized which is stable at temperatures up to at least 2200°F. and will prevent further oxidation of the molybdenum. This self-healing property of clad coatings is useful only for small defects. The nickel molybdate will not bridge across large defects because of the need for intimate contact of nickel with molybdenum during oxidation. Although little work has been done on the protection of the otner refractory metals in comparison to molybdenum, it is believed that similar protective coatings will be developed for them also.

The development of an oxidation resistant alloy having the mechanical properties of the refractory metals would be the ideal solution to the oxidation problem. Considerable research has been done in attempting to develop molybdenum alloys for oxidation resistance without success, and it appears that protection of molybdenum must be obtained from oxidation resistant coatings. Results of recent research on niobium alloys indicate that substantial improvement in oxidation resistance can be obtained through alloying. The addition of titanium, molybdenum, chromium, and vanadium to niobium reduces the oxidation rate considerably as shown in Table 4. However, in each case the oxidation rate is still linear and complete protection has not been achieved. Work is continuing on this problem, and it is anticipated that further improvements in oxidation resistance may be achieved. Ultimately, however, the most probable solution to the oxidation problem will be a combination of protective coatings used on alloys with improved oxidation resistance.

Tantalum being similar to niobium in its oxidation behavior also will probably be benefitted by alloying. Again it would be expected that protective coatings will have to be used in conjunction with alloying to provide as much protection as possible against oxidation.

At present it appears that molybdenum will be the first of these metals to be used extensively in high-temperature applications because of its advanced state of development. Niobium appears destined to be used in high-temperature nuclear reactors where its combination of good strength and low cross section can be used to advantage. Therefore, it appears that its use will follow closely on the heels of molybdenum. Tungsten and tantalum development should not be far behind for they are the two metals which have the highest melting points (and potentially highest strengths) of the metals in adequate supply.

Table 1. Mechanical Properties at 1800°F.

Metal	Tensile strength, lb./sq. in.	Stress to cause rupture in 100 hr., lb./sq. in.	Stress to produce 1% deformation in 24 hr., lb./sq. in. (*14*)
Vanadium	8,000	–	600
Niobium	17,500	14,000(*15*) Lit. cited	6300
Tantalum	21,600	–	7000/9000
Chromium	12,000	–	4500/7000
Molybdenum	29,000	15,000(*9*) Lit. cited	7000/9000
Tungsten	36,500	28,500(*10*) Lit. cited	13,000
Rhenium	85,000	–	–

Table 2. General Corrosion Behavior of the Future Metals (16)

Metal	Corrosion behavior
Vanadium	Resistant to HCl, attacked by HNO_3.
Niobium	Resistant to acids at room temperature, attacked by acids at 100°C and above.
Tantalum	Excellent resistance to acids.
Chromium	Excellent in oxidizing acids because of passivation; will corrode in reducing solution.
Molybdenum Tungsten	Resistant to HCl and HF, rapidly attacked by alkalies in presence of oxygen forming molybdates or tungstates.
Rhenium	Resistant to HCl and HF, attacked by HNO_3 and H_2SO_4.

Table 3. Protective Coatings for Prevention of Oxidation of Molybdenum at Elevated Temperatures

Type of coating	Mechanical shock	Thermal shock	Susceptibility to oxidation through imperfections
Siliconized	Poor	Excellent	High
Chromized	Poor	Excellent	High
Electroplated	Poor	Excellent	Fair if nickel is used
Ceramic	Poor	Excellent	High
Roll cladding	Excellent	Excellent	Low

Table 4. Oxidation Rates of Some Niobium-base Alloys at 1000°C. (19)

Alloy addition	Oxidation rate (wt. gain) mg./(sq. cm.)/(hr.) at alloy content indicated, atom% addition 0	1	5	10	25
Ti	24.2	26.0	15.7	7.7	1.9
Mo	24.2	13.2	4.6	10.1	42.5*
Cr	24.2	33.1	28.1	26.2	6.1
V	24.2	13.8	4.6	3.5	193*

** Large weight gains reflect catastrophic oxidation characteristics of alloying additions.*

Table 5. Stress-Rupture Properties of Some Chromium-base Alloys

Composition, (parts by weight)	Test temperature, °F.	Stress, lb./sq. in.	Rupture time, hr.	Lit. cited
70Cr-30Fe-0.5Ti	1500	23,000	1.3	*21*
70Cr-30Fe-6Mo-2Ti	1500	23,000	7	*21*
70Cr-30Fe-9Mo-4Ti	1500	23,000	450	*21*
60Cr-40Ni-1N-0.17Si	1600	10,000	1.3	*20*
45Cr-52Ni-2.68Si-0.25N	1600	10,000	71.6	*20*

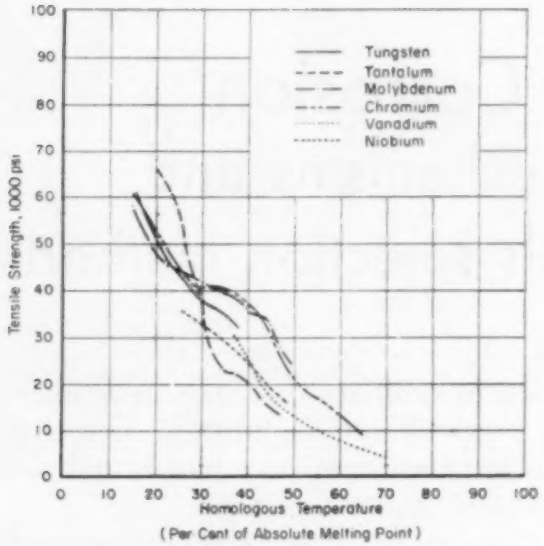

Figure 3. Tensile strengths of the future metals in relation to their melting points (10, 11, 12, 13).

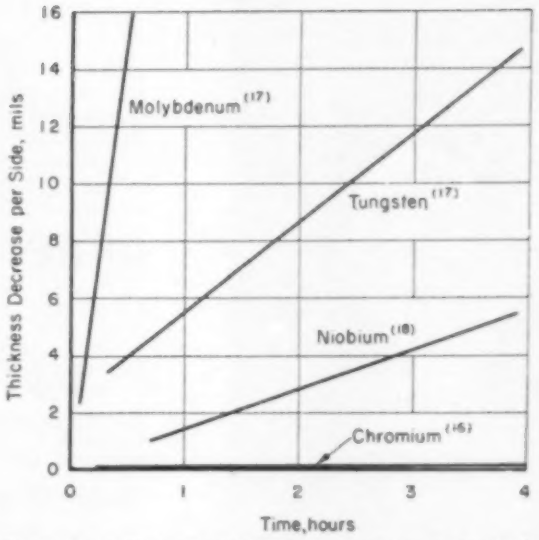

Figure 4. Approximate oxidation rates of the group VI A elements and niobium at 1000°C. in air.

Chromium has the disadvantage of low ductility in the pure state. Present research has indicated that small additions of any alloying element or impurity added to chromium reduces its ductility and raises its brittle-to-ductile transition temperature. On the other hand, the good oxidation resistance of chromium is attractive. Large amounts of alloying additions (on the order of 30 to 50%) to chromium produce alloys which have good fabricability and good elevated temperature properties as shown in Table 5. The maximum use temperature for these alloys will be somewhat less than for the higher melting metals.

One specific use of rhenium taking advantage of its electrical properties should be in high-temperature thermocouples in reducing atmospheres. Only vanadium seems to be borderline with respect to its future in the high-temperature field because of its relatively low strength and poor oxidation resistance.

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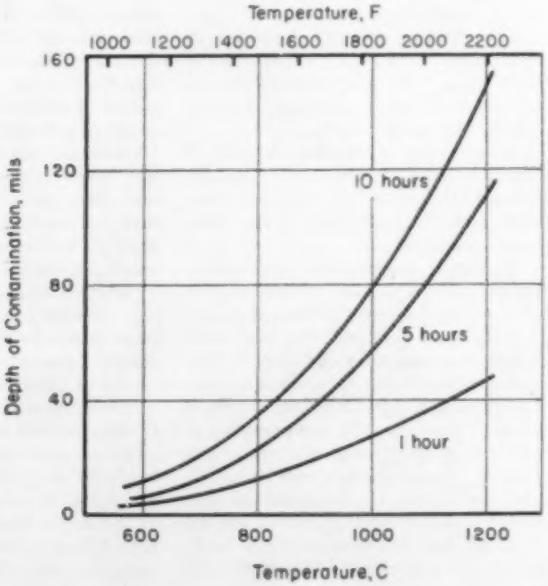

Figure 5. Depth of contamination of niobium by oxygen when heated in air (18).

Presented at A.I.Ch.E. Meeting, Philadelphia, Pa., June, 1958.

OPINION—Here is a straight from the shoulder evaluation of the corrosion picture by Frank LaQue, long associated with the chemical industry's construction materials problem.

Corrosion mechanisms and materials selection methods

. . . a discussion of ordinary materials in ordinary environments . . . a look into the future . . . new techniques for the preparation of pure metals and new possibilities for some common metals . . .

Frank L. LaQue
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THERE has been considerable progress in the development of new and better corrosion resistant materials, in defining and extending the boundaries of their usefulness, and in protecting them from attack where their natural resistance to an environment has not been adequate. But most of this progress has been the result of empirical approaches. Much remains to be discovered by fundamental studies of corrosion processes so as to provide a more substantial basis for even further progress in new as well as old directions.

The energy changes involved in converting ores into metals leave them in a state where corrosion reactions with their common environments are spontaneous.

What needs study are the factors (both internal and external) that determine the rates of corrosion reactions and the mechanics of the reactions themselves.

It should be possible to describe rather precisely those characteristics of a metal that may influence its resistance to corrosion. On the other hand, it is difficult to describe a corrosive environment in a similarly rigorous fashion especially when, as is usually the case, the environment is not only heterogeneous with respect to factors that influence corrosion but also is subject to continual or frequent changes some of which are results of the corrosion process itself. There are also other influences independent of the basic corrosion reaction (e.g., agitation) which can affect it considerably. It is evident that fundamental studies confined to a metal in a particular environment can have only limited applications to behavior in other environments. No matter how much is learned with respect to the features of a metal itself there will have to be extended investigations related to the several environmental conditions that may be of interest.

In view of the many practical instances where either anodic or cathodic polarization (anodic or cathodic control of the driving force) will determine the rate and possibly the location of corrosion, it is evident that study of polarization phenomena will be necessary for a proper understanding of the over-all corrosion reaction and how reduction in corrosion is being or can be accomplished most readily and most reliably. For example, inhibitors can be examined as to whether they function by increasing anodic polarization, cathodic polarization, or both, or whether they simply form films that increase the electrical resistance of the circuit.

Polarization data are still meager. Hydrogen evolution is a possible cathodic reaction which may proceed freely or sluggishly depending on the hydrogen overvoltage characteristics of the metal surface on which the reaction is occurring. A high value for hydrogen overvoltage will result in

considerable cathodic polarization and, therefore, a reduction in corrosion (e.g., pure zinc as compared with impure zinc in sulfuric acid). Consequently, where hydrogen evolution is the expected cathodic reaction, reference to data on hydrogen overvoltage characteristics will provide some guidance in dealing with such corrosion.

Ordinarily, metals are not used in environments where they will corrode so as to evolve large amounts of hydrogen. Some other cathodic reaction is more commonly involved. Usually this is some species of oxygen reduction to yield hydrogen peroxide, water, or hydroxyl ions. Just as in the case of hydrogen evolution, the reduction of oxygen does not proceed with equal facility on all metal surfaces. The phenomenon of oxygen reduction overvoltage can therefore have a great effect on cathodic polarization and therefore on corrosion.

It would be too much to expect a catalogue or encyclopedia of data on hydrogen overvoltages and oxygen reduction overvoltages that will be precisely applicable to all metal-environment combinations of possible interest. Nevertheless, it will be helpful if data can be provided that will afford at least a general classification of metals according to their hydrogen and oxygen reduction overvoltage characteristics under controlled test conditions. A study of these reactions on different metal surfaces may suggest how overvoltages may be altered favorably by changes in the metals or changes in the environment by the addition or elimination of constituents that affect overvoltage. A start has been made in adding to our store of data on oxygen reduction overvoltages *(1, 2)*.

The conductivity of films on the metal surfaces may be of major importance. Insoluble corrosion products may form films having a high electrical resistance and thus stifle further corrosion. Films deposited from the solution may cover the metal with insulating coatings (e.g., carbonate and sulfate films from hard waters). Films of oxide or of oxygen attached to the metal in some other way may represent either an extreme case of anodic polarization or may simply offer a resistance barrier to the passage of current at least in the anodic direction. Either mechanism would achieve a condition of passivity.

What is passivity?

There is still considerable speculation about the nature and mechanism of passivity *(3, 4, 5, 6, 7, 8)*. In view of the evident presence of some sort of film on a passive surface it would appear that an appropriate electron configuration does not achieve passivity directly but rather favors the development of films responsible for passivity. Thus the actual mechanism of passivity may involve some aspects of both the oxide or oxygen film and electron configuration theories. At any rate, the importance of the answer will insure continued research towards a more complete understanding of passivity as a basis for greater assurance in achieving it and preserving it.

Studies of the relationships between applied voltage and current flow have become a useful tool in appraising and developing alloys especially in the stainless steel family that depend on a state of passivity for their resistance to corrosion. Interesting experimental techniques *(9)* make the metal an anode in an environment of interest, and observations are made of the amount of current that flows as the potential of the metal is increased or decreased in appropriate steps. In many instances there are well-defined breaks in the current vs. potential curves. Potentials at one side of the breakpoint are associated with passivity and resistance to corrosion. Those on the other side are associated with activity and susceptibility to corrosion.

Potential *p*H relationships

In view of the profound effects of hydrogen ion concentration on the behavior of metals in corrosive environments considerable attention has been given to the relationships between potential and *p*H in several metal systems. From theoretical considerations and related experiments Pourbaix *(10)* and his associates have developed potential *p*H diagrams for a number of metals. These may be used to show whether corrosion will or will not occur under certain environmental conditions related to the chemical nature of the possible corrosion products and the potential of the metal as determined by its environment. Data of this sort will provide a valuable supplement to empirical tests for deciding which environmental conditions will be and which will not be favorable in choosing a metal for a particular service or in altering an environment or the potential of a metal by application of current so as to reduce or eliminate corrosion.

Cathodic protection

The conception of corrosion as being an electrochemical process provides a natural basis for controlling corrosion by manipulations of potentials and currents. The process of preventing or reducing corrosion by forcing current to flow to, rather than away from, the metal is called cathodic protection. To be successful, it is necessary that the amount of protective current applied be sufficient for the purpose and that the arrangement of the system be such that current can, and will reach all surfaces requiring protection. This presents considerable practical problems where it is necessary to get current to such points as the remote inner surfaces of small diameter tubes, such as are frequently used in chemical process heat exchangers.

A more basic theory (than the conventional one) for cathodic protection suggests that corrosion is eliminated by supplying from a chosen external source all the electrons required to accommodate the original cathodic reactions so that none will be needed from the original corroding anodes. These anodes will then participate in a spreading induced cathodic reaction as a substitute for the initial anodic one. This theory attaches less importance to the potential of the original anodes as a basis for control and substitutes more concern with the nature of the cathodic reactions that are induced and the potentials at which they occur. In any event, it is necessary that more be learned about the theory and mechanisms of cathodic protection if it is to be applied intelligently and successfully to metals and equipment more complex than the underground iron and steel pipe lines, ships hulls, and the relatively simple systems with which it has been used so successfully.

Up to now, the greatest application of cathodic protection in chemical engineering has been to reduce corrosion—not so much to prolong life of equipment as to reduce metallic contamination of the material being processed or transported. Under such circumstances the distribution of corrosion to all surfaces requiring protection is not so critical. More attention to current distribution will be required where success will depend on protecting all of the metal rather than only some large fraction of it.

continued

Corrosion mechanism

continued

Pitting and other forms of localized attack

The teachings of corrosion theory and practical experience are generally sufficient to avoid difficulties arising from misapplications of metals in the form of failure as a result of excessive over-all attack. What are likely to be most troublesome are instances of highly localized corrosion which appears as perforating pits surrounded by large areas of substantially unaffected metal, penetration by destruction of the boundaries of otherwise unattacked crystals or failure as a result of the propagation of cracks resulting from the combined effects of corrosion and stress.

There has been enough study of these phenomena to provide a fair record of the metal-environment combinations where they have been observed most frequently. There are also plausible suggestions as to the mechanisms of the reactions involved in pitting *(11, 12, 13, 14)*, intergranular *(15)* corrosion, and stress corrosion cracking *(16)* in particular instances. But there is still no satisfactory fundamental basis for predicting which metals will be susceptible to these damaging forms of corrosion in particular environments nor for characterizing environments as to their power to corrode metals in these insidious ways.

It is not too difficult to account for the progress of a pit once it has started. But it is not easy to describe the difference between one point and another on a metal surface so as to distinguish those at which pits start from those which remain unaffected while perforation has occurred elsewhere. If the causes of these fundamental weaknesses or areas of abnormal activity could be discovered, it would be easier to devise or treat alloys so as to make them less susceptible to pitting.

It is simple enough to postulate that intergranular attack can be the result of the presence of a grain boundary network of a phase different in composition from and anodic to the bulk of the metal. But why is such a network attacked preferentially by a particular solution such as boiling nitric acid while it resists some even more corrosive solutions as well as does the rest of the metal? In the case of stainless steels is the intercrystalline zone attacked because it is depleted in chromium or has it be-

New Ways to look at Corrosion Processes

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Most studies of corrosion have been carried out by testing the metal or alloy under simulated corrosive atmospheres. Although practical solutions to the problems are frequently found using these methods, few fundamental answers are obtained. The major difficulty in undertaking fundamental studies arises from the fact that in many cases the usual protective film present is only a few angstroms thick. As a result, this oxide film has several unique structural features which are not easy to study by methods now available.

Electron diffraction studies

Table I shows a summary of the crystal structures of the oxides formed by oxidation of iron, cobalt, nickel, chromium, and copper between 300° and 700° C, as determined by electron diffraction techniques at the Westinghouse Research Laboratories. Four oxides of iron are observed. Transformation occurs in the oxides formed on iron during reaction and as a result of temperature changes.

The poor protective properties of iron can be related in part to these transformation reactions. Chromium and nickel form only one oxide over the temperature range and have much superior protective properties. Copper forms two oxides. However, CuO is not usually observed in the oxygen atmosphere used in the electron diffraction camera.

These results show that electron diffraction analyses can be very useful in identifying the crystal structures and composition of the surface oxide film on metals.

Electron microscope studies

In a study of stress corrosion cracking, we assume that cracking is probably due to a highly localized chemical or electrochemical attack of the metal with the local attack being accelerated by stress and by special ions such as the chloride ion. We propose that, localized attack of a surface manifests itself in unusual crystal habits or form of the reaction products.

Direct transmission electron microscopy was used to study the crystal habit of the corrosion products of suitable specimens.

The results on various samples are as follows:

A. "Armco" Iron

Iron discs were reacted at 500° C. in oxygen for 17, 107, and 220 hours.

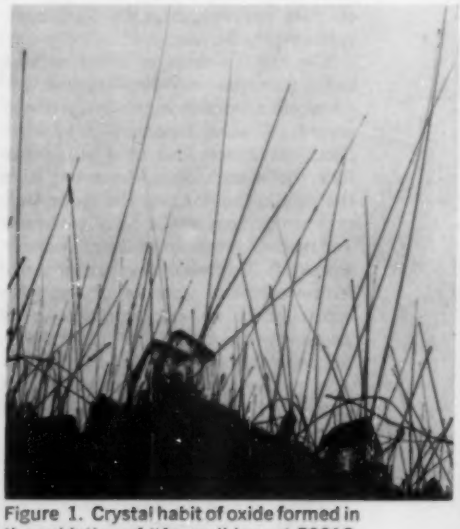

Figure 1. Crystal habit of oxide formed in the oxidation of "Armco" iron at 500°C.

Table 1, Oxide Films Formed on Metals

	Temperature, Degrees C					
Metal	200	300	400	500	600	700
Iron	$\gamma-Fe_2O_3$	$\alpha-Fe_2O_3$	Fe_3O_4 + $\alpha-Fe_2O_3$	Fe_3O_4	FeO	FeO
Cobalt		Co_3O_4 + CoO	Co_3O_4 + CoO	CoO	CoO	CoO
Nickel		NiO	NiO	NiO	NiO	NiO
Chromium		Cr_2O_3	Cr_2O_3	Cr_2O_3	Cr_2O_3	Cr_2O_3
Copper		Cu_2O	Cu_2O	Cu_2O	Cu_2O	...

come more reactive because of some change in energy level associated with mismatches of adjacent crystals and, if so, why does this have this effect in some environments and not in others. These and other equally pertinent questions applicable to many metal-environment combinations in which intercrystalline attack occurs remain to be answered by future research projects which can provide the basis for elimination of corrosion problems of this sort.

Stress-corrosion cracking is even more elusive since prediction of difficulties from this source depends almost wholly on accumulated experience to define the circumstances under which it may occur. With some systems such as steel in caustic soda solutions there are some general rules *(17)* involving limits of stress, caustic concentration, and temperature which will serve as a general guide to the avoidance of difficulties. But even with this well-studied system little is known for sure about the mechanism of the attack. Hydrogen embrittlement has been suggested as the basic mechanism *(18)*. The complexity of the problem is indicated by the observation that it is difficult to crack steel in very pure caustic soda solutions but that when a little lead monoxide (0.2%) is added intergranular cracking occurs readily while the addition of a little sodium silicate (0.3%) is equally potent in stimulating cracking but this time the cracks are transcrystalline. It is difficult to suggest the presence of anodic networks which shift their position with such apparently modest changes in the character of the environment.

Again, in the chromium, nickel, iron system, chloride solutions appear to have a specific power to induce transcrystalline stress corrosion cracking and in this respect are quite different from other environments capable of causing as much or more localized pitting as well as general attack. What is the mechanism that accounts for the effects of nickel in this system? When susceptibility to cracking in alloys that contain 18% Cr is related to the nickel content of the alloy, it is observed that maximum susceptibility occurs with a nickel content around 8% and then decreases rapidly so that it is very

continued on next page

Small oxide whiskers formed on the discs during the 17-hour experiment. The thickness and length of the whiskers increased with time of reaction. After 220 hours of reaction in dry oxygen, the oxide whiskers had grown to lengths up to 300,000 angstroms and to thicknesses of the order of 1000 angstroms. The density of oxide whiskers was 10^8 to 10^9/sq. cm.

Figure 1 shows a typical electron micrograph of the whisker growth. The ball shape of the ends of the whiskers was due to local melting of the whisker while being studied in the electron microscope.

Electron diffraction studies on these samples show the whiskers to be single crystals of α-FE_2O_3. Figure 1 shows also the formation of a few thin platelets of oxide. The thickness of these platelets is estimated to be about 100 angstroms or less.

B. 304 Stainless Steel

304 stainless steel disc samples were also reacted at 500° C. for 17, 107 and 220 hours. Small oxide whiskers form for times less than 17 hours. The whiskers are of smaller size and fewer in number than those found on "Armco" iron under similar conditions. Only a few areas of the hole appear to be covered with whiskers. An electron micrograph showed that the oxide "whiskers" formed after 17 hours of reaction in dry oxygen at 500° C. After 220 hours of reaction the oxide whiskers reach a thickness of 600 angstroms and a length of 60,000 angstroms.

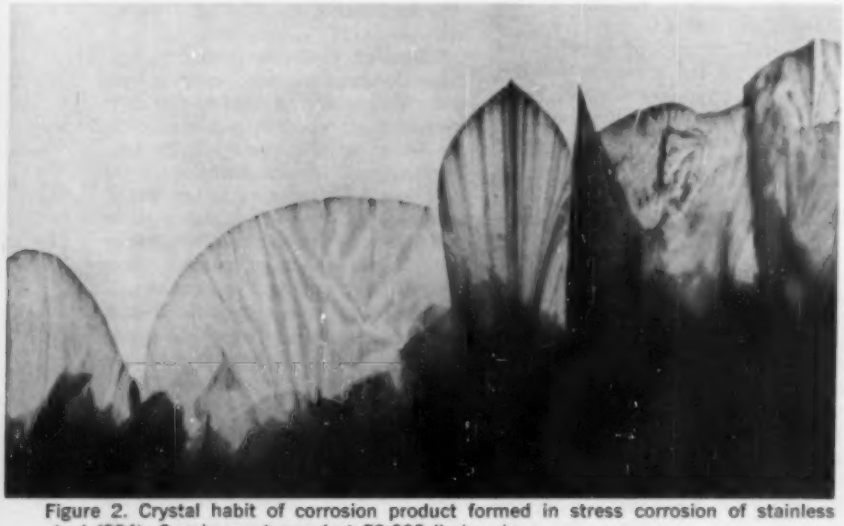

Figure 2. Crystal habit of corrosion product formed in stress corrosion of stainless steel (304). Specimen stressed at 59,000 lb./sq. in.

If a sample of 304 stainless steel wire is prestressed to the elastic limit and reacted at 600° C. for 138 hours with wet oxygen plus a trace of hydrochloric acid, a new type of crystal habit occurs in the corrosion product. Large platelets of oxide are found instead of whiskers. Figure 2 shows an electron micrograph of the sample. The platelets were readily penetrated by 60-kv. electrons and we estimate the thickness to be about 100 angstroms. The platelets grow perpendicular to the surface of a parallel arrangement to a height of 100,000 angstroms and to a length of over 250,000 angstroms. Electron diffraction analyses show the platelets to be Cr_2O_3 and single crystals.

The formation of long oxide whiskers and thin oxide platelets are amazing crystal forms resulting from a chemical reaction. Thermodynamic considerations would predict the formation of crystal shapes with minimum surface areas.

A primary question that still must be answered is, "What is the nature of the metal at the root of the whisker or platelets?" If deep pits or trenches are formed, corrosion under stress has led to chemical cutting of the metal.

Conclusion

If the implications of these results can be substantiated, we will have a new method of predicting the type of corrosive attack a metal will undergo and what treatments should be started to prevent this type of corrosion.

Condensed from a paper presented at the Annual Machine Tool Electrification Forum sponsored by Westinghouse, 1958.

At his desk, LaQue explains the fine points of corrosion to CEP interviewer.

Corrosion mechanisms

continued

low when the nickel content is around 40% and disappears entirely at the 75% Ni level in the alloy Inconel. Is this due to some basic effect of the nobility of the alloy constituents or is it somehow related to the presence of minor constituents such as carbon and nitrogen *(20)* which, are in some way responsible for the cracking that occurs only when they are present above some critical limits? Are the attacked phases present from the start or are they formed as a result of the effects of the stress that eventually tears the metal apart *(21, 22)*.

It is evident that much remains to be learned about the mechanisms of stress corrosion cracking so that susceptibility to this form of damage can be predicted and difficulties avoided by means other than the teachings of bitter experience. It is likely that answers to these and other questions *re* stress corrosion phenomena will be forthcoming.

The future

In the future there will be a need for more attention to special corrosive media such as molten salts and slags, molten metals, and complex organic compounds. There also will be concern with effects of radioactivity on the corrosivity of environments and the corrosion behavior of metals about which little is known now. New techniques for preparing pure metals and for identifying and controlling microconstituents may be expected to open up new possibilities for greater chemical stability of some of our common metals with a consequent broadening of their fields of usefulness. Finally, there will be a raft of new alloys including not only additions to the systems already in common use but also some of the more exotic ones.

The usefulness of these metals for specific purposes will have to be appraised so that they can be applied advantageously to help solve corrosion problems of the future.

Tables of corrosion resistance

Some producers of corrosion resisting materials aided and abetted by publishers of some technical journals have endeavored in good faith to simplify the selection of materials for particular corrosive environments by setting up lists of chemical solutions in a table so that the ability of the material to resist an environment is indicated by an appropriate check mark, a symbol, or even by a figure, for a probable rate of corrosion. Such tabulations are undoubtedly interesting and deceptively attractive since they suggest a short cut to the solution of a complex problem. They are much more likely to indicate an appropriate or at least safe course of action when they show that a metal is unsatisfactory for a particular environment. But there are many pitfalls when there is a suggestion of probable suitability since the conditions of indicated suitability may not include those of the actual use. There is never enough room in such a table to take into account all the important effects of concentration, temperature, velocity (agitation) aeration, chance impurities, etc. that may determine the success or failure of the material.

Furthermore, tables of this sort may suggest a long list of possibly usable materials without any proper grading of them as to their probable order of merit. Thus the problem of selection after use of the table may be not much less than before such use. It has been the author's experience that tables of this sort are more attractive than useful and are, fortunately, used very rarely, if at all, for the solution of any really important corrosion problems. These should receive expert attention by user and producer specialists as mentioned previously.

Process plant corrosion tests

Because of the limitation of laboratory corrosion tests there has been a considerable development of the practice of exposing corrosion test specimens in operating equipment so that they will encounter the corrosive environment under the actual conditions of service including the normal fluctuations in these conditions over an extended period of time which will usually be much longer than is likely to be used for a laboratory corrosion test. An extension of the author's general method is now incorporated in an A. S. T. M. procedure for Plant Corrosion Tests *(30)*.

A special variety of such "in plant" tests is the fairly recent practice *(31)* of installing specimens of the metal in use in the plant in locations where corrosion has occurred or is anticipated. Such specimens are made part of an electrical circuit so that as they suffer corrosion the reduction in cross-sectional area will be disclosed as a measured increase in their electrical resistance. In this way, the progress of corrosion can be monitored so as to provide a continuous check on whatever may be done, e.g., the use of inhibitors, to keep corrosion in bounds and under effective control.

Hot and Cold Wall Effects. While tests in the plant have a better chance than laboratory tests of indicating the probable performance of materials in a particular service, they cannot cover all the conditions that may be important. For example, this method will not permit observation of hot wall effects when the surface of the metal, as in the case of a steam coil or heater tube, is hotter than the solution and may therefore suffer more or sometimes less corrosion than the same metal suspended in the solution. Likewise a specimen that is not cooled may not encounter the corrosive effects on the surface of a cooler tube, especially if there should be condensation on the tube and not on a specimen suspended in vapors at a temperature above their dew point.

One way around these difficulties is to install test tubes in an operating heater or cooler bundle. But here there is always the danger of galvanic effects which have to be taken into account in interpreting the results.

Effects of corrosion products. Another factor that may upset plant tests of any sort is that introduced by effects of corrosion products from the metal or metals already in use. For example, copper corrosion products would be expected to accelerate corrosion of less noble metals such as aluminum steel or nickel while they might protect a passive alloy like stainless steel.

Pilot plants. Sometimes there isn't an operating plant in which specimens can be exposed. In such instances, and others where the final plant is important enough, the best practice is to build a pilot plant using either the cheapest or, better, the most promising materials and observe their performance under small-scale operating conditions. It is

sometimes possible to extend the information to be gained in this way by exposing specimens of many materials in the pilot plant.

Velocity effects. One of the most difficult factors to deal with in corrosion tests in the laboratory or in the plant is that involved in effects of velocity or turbulence especially at a high level. It is almost impossible to establish a precise relative velocity between a metal specimen and a liquid in which it is immersed. When the metal is moved it drags a layer of liquid along with it. When the solution is moved there is usually a film of liquid that moves more slowly next to the metal surface. There is also a big difference in corrosive effects between a fairly uniform distribution of velocity and one involving steep velocity gradients such as may be achieved by the action of jets or by spinning disks, etc. The latter are usually much more damaging and thus are likely to be more discriminating in appraising the relative merits of different metals in resisting attack where severe velocity or turbulence effects are anticipated.

Effects of surface condition stress and heat treatment. The problem of making a selection from a number of possibly suitable metals by running corrosion tests on them is complicated by the usual necessity of taking into account possible effects of such factors as the surface finish, heat treatment such as that incidental to welding, and stresses from fabrication or applied in service. To examine all these factors with all the materials of interest would make most test programs unwieldy. A reasonable procedure is to test all of the materials of possible interest in what might be called their best condition with respect to these factors. This will usually call for annealed specimens having a reasonably smooth surface which is substantially the same for all metals tested. Only those metals that show promise when tested in this favorable condition need be subjected to more critical tests to discover whether resistance to corrosion is likely to be affected to an important extent by surface finish, heat treatment, or stress. In connection with the stress, in the absence of applicable data or experience it is prudent to assume that there may be some adverse effects of stress, and explore this possibility by exposure of appropriately stressed specimens. Since residual stresses from fabrication are usually more damaging than the stresses of service, it usually will suffice to expose specimens stressed beyond their yield strength by some sort of deformation such as by bending to the shape of a horseshoe with the open ends under restraint or by a permanent indentation such as may be achieved by an Erichsen cup test for ductility.

Since the heat treatment effects associated with a weld on a test specimen are under poor control and are difficult to reproduce exactly, it is frequently desirable to supplement the exposure of test welds by the inclusion of specimens that have been given a sensitizing heat treatment under controlled and reproducible conditions which are likely to be more damaging than any welding operation is likely to be. The use of such sensitized specimens will greatly facilitate the interpretation of results of tests carried out to disclose possible welding heat effects.

Qualification tests. Some early experiences with stainless steels in the chemical industry have led to the use of what are called qualification tests. The most common of these *(32)* continues in use in accordance with an A. S. T. M. Specification A262-55T *(33)*. Another test *(34)* for a similar purpose uses a mixture of sulfuric acid and copper sulfate and is covered by A. S. T. M. specification A393-55T(35). Still another qualification test makes use of nitric hydrofluoric acid mixtures and recently there had been added a new one based on ferric sulfate in sulfuric acid. Since these tests are time consuming and are frequently used for specification purposes, there has been considerable interest in a test for screening lots of metal so that shipments might be accepted without further qualification by prolonged tests. This has been achieved by the electrolytic oxalic acid etch test *(36)* and accepted by the A. S. T. M. as a means of screening specimens from the longer tests.

In 1950 the A. S. T. M. held a symposium devoted to a critical survey of several of these qualification tests (37). The proceedings from this will provide a fair picture of the advantages and limitations of tests of this sort.

Undoubtedly these tests have been of great help in developing stainless steels free from bad effects of certain heat treatments including those incidental to welding and, as used for inspection, have detected lots of stainless steel that might have given trouble in service. At the same time, any tests, such as these which use an arbitrarily chosen corrosive environment to qualify a metal for use in some quite different environment, must be used with considerable discretion. This is especially the case if they should be used mistakenly to choose materials for some particular environment not closely related to that of the test. There is also a danger that if these arbitrary tests are used as a research tool in the development of new or improved alloys, the result may be a distortion of the area of practical usefulness of the metals in the direction of favoring performance in the test environments at the possible expense of performance in other environments of greater practical interest. Another possibility is that metals composed or fabricated to meet an arbitrary qualification test may become more expensive than is necessary for the actual use in hand.

Conclusion

A continued concentration on empirical approaches to the solution of corrosion problems will achieve advances in the customary, somewhat plodding step-by-step fashion. A greatly increased attention to basic research on the fundamentals of the subject will be required if any major "break throughs" are to be achieved.

It is equally evident that if real progress is to be made there will have to be at least as much effort to add to our fundamental knowledge in this field as to find immediate solutions to practical problems by empirical approaches.

The Corrosion Research Council recently organized under the auspices of the Engineering Foundation should be useful in coordinating basic research in this field through the activities of its Advisory Committees, which are classified according to surface reactions, electrochemistry, and stress corrosion.

The Council will also appropriate research projects with funds to be furnished by industry. It would appear to be in order for the chemical industry to support the program of the Corrosion Research Council.

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Future trends in application of rubber in chemical engineering

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What about the future for rubber as a construction material for chemical process applications? There is a known demand, both military and industrial, to extend still further the range of chemicals and solvents with which rubbers can be used. In particular there is a demand for elastomers to resist esters, highly aromatic and chlorinated hydrocarbons, and powerful oxidizing chemicals, not only alone but in mixtures with each other and with less effective materials, or alternating between different materials. There is a continual demand for rubbers to withstand both higher and lower temperatures. With the development of nuclear power and the chemical uses of radiation there will be demands for elastomers to withstand radiation effects. Of course, nearly all combinations of these various properties are wanted by somebody.

There is little question that these demands will be met in the future though it would be premature to say how or when. One of the most recent of the elastomers to be announced is Viton *A*, a copolymer of perfluoro propylene and trifluoroethylene. It is reported that it shows remarkable resistance to chemicals and maintains its quality for long periods of time at temperatures above 400°F. Other fluorine elastomers may be anticipated and some may have still better properties. There is no indication of any slackening in the studies of all kinds of organic high polymers. There is also continuous development of the silicone polymers. Other hybrid polymers where the silicone is replaced by other inorganic elements or groups are likewise under investigation. In addition to these approaches there is undoubtedly a considerable volume of research and development under way about which nothing is yet known outside the laboratories where the work is being done. From all this work we are sure to get new elastomers which will gradually extend the range of conditions under which the desirable qualities of rubbers can be utilized.

At the same time studies are continuing on such compounding materials as pigments, vulcanizing agents, adhesives, etc., and developments here will lead also to improved rubber compositions. Basic studies on what happens during vulcanization, stress-relaxation, aging, etc. are increasing our knowledge of these phenomena. Such increased knowledge will lead to new ideas and to the development of improved physical properties in the rubbers already available.

On top of these developments there are signs of growing interest in the development of new uses and new constructions which utilize elastomer properties for the chemical process industries.

The more chemical engineers specializing in plant design or operation understand the advantageous use of rubbers, what they will do and will not do, the more probable are new developments in their use. Also the more compounders and engineers in the rubber industry know about the problems of chemical engineering, the more probable it is that they will help solve those problems. It is from this type of interplay of knowledge that the most spectacular developments can be expected.

Presented at A.I.Ch.E. Golden Jubilee Meeting, Philadelphia, Pa.

Ceramic materials for high-temperature applications in the chemical process industries

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CERAMIC materials are inorganic, nonmetallic compounds made or used at high temperatures. They are generally brittle, difficult to fabricate, nearly impossible to machine, and from these standpoints much less attractive than metals as materials of construction for chemical equipment. However, there are many conditions, particularly at high temperatures (greater than 1500°F.) where metals deteriorate rapidly. Ceramic materials, because of their greater resistance to temperature and to certain specific environments, are often used under such conditions where metals are not satisfactory. Some typical ceramic materials that are used in high-temperature chemical processes are listed in Table 1. These materials are used in such a great variety of applications that it is not practical to indicate specific applications for each. The general use, and the most common limitations of the various ceramics are shown. With the exception of refractory concretes, the compositions of the ceramic materials are evident from their names. Refractory concretes are composed of a mixture of aluminous cement (similar in working characteristics to ordinary Portland cement but having greater temperature resistance) and aggregates having suitable temperature resistance.

Recently developed processes in which ceramics are used

Some of the more recent high-temperature processes that have been dependent on the development of suitable construction materials are listed in Table 2. One of the most recent of these is the Tennessee Eastman process for the production of acetylene from hydrocarbons. It was announced at the A.I.Ch.E. meeting at Chicago in 1957. In this process, acetylene is produced by breaking down saturated hydrocarbons rapidly in hot combustion gases. The process uses a specially designed furnace lined with stabilized zirconia. A fuel such as natural gas is heated to about 1100°F. in a preheater. From there it goes to the burner in the furnace combustion chamber where it is mixed with a preheated oxygen-steam mixture and is burned at a calculated flame temperature of about 3600°F. A preheated mixture of hydrocarbon cracking feed and low-pressure steam is fed into the stream of high-velocity combustion gases resulting in cracking of the hydrocarbon. The products are quickly cooled with a water spray and the exit stream is processed to separate the desired products. The zirconia lining of the furnace is designed to withstand temperatures up to about 4500°F. Suitably stabilized zirconia for this application has been available only for a relatively few years.

Future needs

The development of new high-temperature chemical processes will require an associated development of new materials. Some of the potential high-temperature processes that have been proposed include ozone from oxygen, direct synthesis of cyanogen from carbon and nitrogen, and additional production of valuable products by thermal decomposition of gases (butadiene from butane, for example). The recovery of beryllium as the chloride from a beryllium ore by high-temperature chloridization has been tried on a pilot-plant scale. Speaking generally, some processes undoubtedly will be developed that will operate at temperatures and under conditions where present-day commercial ceramic materials are perfectly satisfactory. Others will be developed where the temperature will be a little too high or the corrosive conditions a little too severe for present-day materials, and a ceramic material will be tailormade for the process by modifying those that are now available. Still others will be developed where the temperatures are so high or the corrosive nature of the reactants or products such that none of the present-day commercial ceramics come even close to being usable. For some of these very high temperature processes, the problem may be solved without developing a new refractory. Perhaps a water-cooled metal container can be used. The problem of finding a refractory crucible to contain molten titanium was handled in this

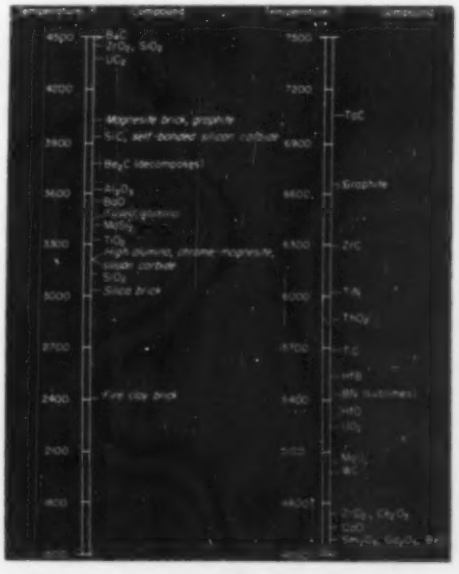

Figure 1. Upper operating temperatures of commercial ceramics and melting points of pure compounds.

way. Or perhaps, the reactants can be used as the container. The problem of finding a crucible to contain the highly corrosive molten fluoride batch employed in synthesizing mica was handled in that way. But these two expedients, cooling the refractory or using a portion of the reactants as the container, will not be practical in every case, and there will still be the problem of developing higher melting, more stable, and more chemically resistant materials than we now have.

Future developments in ceramic materials

Melting point is a major factor to be considered in attempting to assess the potentialities for future development of new materials. The approximate upper operating temperature for commercial refractories and the melting points of some pure compounds are shown in Figure 1. The commercial materials are indicated in italics and the pure compounds in ordinary type. A striking feature of this temperature chart is that the upper operating temperatures for the commercial materials are appreciably lower than the melting points of the corresponding pure compounds in many cases. Magnesite refractories, for example, are useful only up to temperatures about 1000°F. below the melting point of magnesium oxide. Although operating conditions, particularly the load to which the commercial material is subjected in use, account for a good deal of the spread between the commercial material and the pure compound, it is apparent that there is considerable improvement possible with the present materials. Between 4000 and 5000°F., zircon, zirconia, beryllia, rare earth oxides, and magnesia are possible refractories. These are not particularly exotic materials and their prices, with the possible exception of the rare earths, are within reason. However, it must be noted that the environment in which the material is to be used can be the major factor in determining its utility; and under specific conditions, the maximum use temperature of these compounds might be well below 4000°F. Above 5000°F., graphite is probably the only practical possibility, and it is limited to use in reducing or neutral atmospheres. Cost and/or availability fairly well eliminate the other compounds melting above 5000°F. Although new high-melting compounds undoubtedly will be discovered, it is highly unlikely that they will be composed of the more abundant elements, and accordingly these new compounds also are likely to be unavailable in the quantities needed for refractory applications even at a high price.

Hence, the prospects look dismal above 5000°F. But, it seems unlikely that the problem of selecting a material to contain a chemical process operating at, say, 7500°F. will reach the engineering stage. It is likely that some expedient such as cooling the walls, use of the reactants as the container, or levitation would be employed in developing the process and be adapted to commercial operation.

Presented at A.I.Ch.E. Golden Jubilee Meeting, Philadelphia, Pa.

What is the future of ceramics for chemical processing applications?

In the future it is expected that there will be refinement in equipment design and lines of product. With the developing trend to processing at higher temperatures and pressures, there will be more security built into porcelain piping. It is expected that in the near future steel armored porcelain pipe and fittings, which will be reliable for operating temperatures up to 400°F. and pressures up to 150 lb./sq. in. will be available. Improved higher strength, higher temperature ceramics will certainly develop commercially. More is being done in the research laboratories with high alumina bodies which give promise of raising the strength of commercial high-grade porcelain by two to three times. Such bodies can probably be operated at far higher temperatures and sustain more severe thermal shock conditions than is true with chemical procelain bodies today.

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A. O. Smith Corp.

From a paper entitled "Ceramic Materials for Corrosion Resistance," presented at the A.I.Ch.E. Golden Jubilee Meeting, Philadelphia.

Table 1. Some typical ceramic materials used in chemical processing at high temperatures

Type	Approximate upper temperature limit, °F.	General use	Limitations
Alumina-silica brick (Fire clay to high alumina)	2400-3200	Extensively used in nearly every high-temperature industry	Melting point, chemical resistance
Silica brick	3100	Primarily where temperature held steady	Melting point, resistance to thermal shock[1]
Magnesite brick and mixture of chrome ore with magnesite	3000-4000	Mainly where in contact with basic slags	Acid resistance
Chrome brick	2900	Primarily as separator between acid and basic brick	Melting point
Silicon carbide	2800-3200	Muffles and recuperators	Oxidation resistance
Fused alumina	3400	Muffles and recuperators	Cost
Graphite, carbon	4000	Arc electrodes, furnace hearth linings	Oxidation resistance
Refractory concrete	3200	Reactor vessel linings	Erosion resistance

[1] Silica has excellent thermal shock resistance if kept above about 1100°F.

Table 2. Some recent high-temperature processes

Industry or product	Approximate temperature, °F.	Ceramic materials used
Nitric oxide (Cottrell Process)	3800	Magnesia brick and pebbles
Nuclear reactors (gas cooled)	Above 1500	UO_2, UC_2, BeO, graphite
Petroleum cracking	1500	Al_2O_3, refractory concrete
Synthetic mica	2500	Unmelted batch
Acetylene (Tennessee Eastman)	3600	Stabilized zirconia

A system for

Evaluating the need for a pilot plant

J. E. Pierce, *Dow Chemical Co., Midland, Mich.*

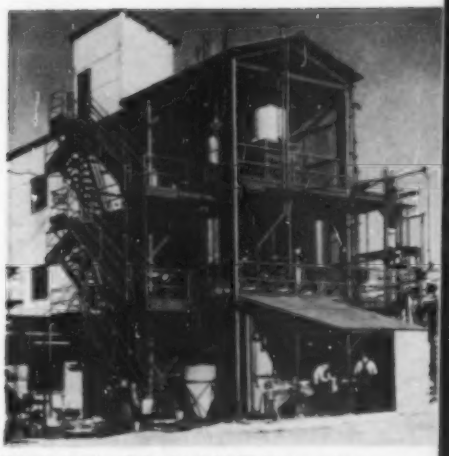

Figure 1. A pilot plant built for a specific project.

A systematic procedure involving three analytical methods can coordinate the development of pilot plant projects from earliest steps to preparation of authorization requests. Duplication of written information is held to a minimum while establishing the cooperation of all contributing departments.

All engineers experienced in development of chemical processes know how important it is to plan a pilot plant operation carefully. Some background on the need for detailed planning of the technical work in relation to economic and market considerations can be obtained from the literature (*1-5*).

Since pilot plant work can be expensive, preparatory work in identifying the key problems will be a wise procedure. In addition, time will generally be saved by doing a thorough preliminary job in the laboratory, and with the slide rule, before attempting to operate larger scale equipment.

Once a large pilot unit is operating it is difficult to stop as an unsuccesful project. The answer is always "just around the corner," and requires "just one more" revision of equipment. It pays, therefore, to know exactly what is to be done in the larger equipment and to have prior commitment on a definite program.

This article outlines a systematic plan which has gradually evolved at The Dow Chemical Company, through selection and trial, from various techniques used in different departments throughout the company. In light of the company's philosophy of participative management in research, experimentation with improvement of the system will continue. Only the main features of the procedure will be outlined here, since the specifics would have to be altered to suit any other organization.

If the operating scheme were perfect it would:

1. Show answers to all important questions
2. Properly fix responsibility
3. Provide all necessary communications
4. Eliminate duplication of reporting
5. Hamper no one's creativity or aggressiveness.

These goals can only be approached. The procedure outlined, however, is reasonably successful. Methods described do not, in the usual sense "control" research. They do furnish a means by which assistance in the company can be brought to the research man's aid. He will then control himself, for no one wants an unsuccessful project.

Pilot plant expenditures are forecast and authorized for individual projects. Each is a particular case handled on its own merits. Funds for facilities and hiring of personnel are made available if the desirability of a project is demonstrated.

A proposal for a pilot plant is initiated and crystallized by those who are going to carry out the operation. It is vital for them to have all information pertinent to their project. Operational steps should be written in a recognized way, consistent from project to project, so as to demonstrate the planner's knowledge. Supervision can then be sure of adequate information exchange, of a uniform understanding of goals, and an appreciation of the problems of cooperating departments.

Planning for a pilot plant begins very early, that is, long before the

continued

Pilot plant

continued

pilot plant is needed. Three over-all analysis methods are used.

1. Stage system
2. Project evaluation
3. Authorization request check list

Each of these requires information in some or all of the following particular reports:

1. Economics
2. Investigation plan for pilot plant
3. Market goals
4. Patent report

Every research project should be recorded in the stage system. Many of these are dropped before reaching the pilot plant stage. Others, even if successful, will not require a pilot plant, so the complete procedures are not required. For those which involve entirely new products, requiring, if successful, an investment in a new production plant, all steps in the operation are necessary. Another variation would be a process improvement for an old-line product, such as chlorine. Here a market study would not be necessary if the improvement were merely to cut costs and not expand production.

The above comments merely point out that judgment is needed, both by the research group preparing the proposal for a pilot plant, and by management in reviewing the papers, to see that an adequate job has been done.

Stage system

The stage system is a method of classifying all research projects according to their progress toward commercialization. It has other uses besides planning pilot plants, but has nothing to do with size of equipment or amount of money being spent. It is used by laboratory directors in analyzing their own projects and in judging when and how a pilot plant will be useful.

Each laboratory normally proposes and operates the pilot plants on projects which it has originated. It is the responsibility of the laboratory director to see that patent, economic, engineering, and market questions have been satisfactorily answered either in his own organization or through consulting departments. The stage system form obtains personal commitment by checking suitable statements without demanding preparation of a written report. This system will work well only if the laboratory director makes clear assignments of responsibilities, and holds regular periodic meetings to coordinate all phases of his goals. There are four stages, as follows:

Stage I Exploration—early stage projects only vaguely focused.

Stage II Examination — intensive laboratory development; sustained effort on a project aimed at a definite commercial goal.

Stage III Confirmation—final stage of evaluation; obtaining adequate process and product data, so that a decision to produce can be made. (This stage usually requires 6 months to 2 years).

Stage IV Commitment—the company has made a commitment in the form of authorization of commercial production facilities, or commitment to deliver to a customer, such that responsibility for the project has in part or completely passed from research to production and sales groups, with research playing a supporting role.

The laboratory director decides when a project is ready to move to a higher stage. Promotion occurs simply by making out a new form to replace the one existing. However, in order to enter Stage IV certain responsibilities must have been passed to, and accepted by, other departments.

The questions raised by this system fall in the following categories:

Check list:

- Synthesis—preferred method
- Synthesis—alternate methods
- Raw materials
- Applications—other uses
- Sampling (extent of sample distribution)
- Product quality
- Engineering data
- Patents
- Product name and trademark
- License and know-how purchase
- Toxicology
- Safety problems
- By-product studies
- Materials of construction
- Process control and analysis methods
- Specifications
- Economics
- Waste disposal
- Handling and shipping
- Time required to reach Stage IV

As projects progress toward Stage IV, answers become more specific.

There are many values in the stage system but in the field of pilot plant planning the merit is that it ensures that the originating group does consider all the major aspects involved. The check list points out questions which might otherwise be recognized so late that the project would be delayed.

Miniplants

In many cases the process engineers may find that a "miniplant" can be useful in one of the stages. A miniplant is a complete bench-scale laboratory operation of the proposed process. Commercial raw materials, commercial materials of construction, simulated production instrumentation, and recycle operation if applicable, should be used. Such an operation can define the need for design changes and so avoid time-consuming difficulties when on a larger scale. Even when it is clear that a large pilot plant will be needed to supply material for market investigation, a miniplant can be valuable (Figure 3). Time and money can be saved by demonstrating that the large pilot plant will probably operate successfully. As an example, a complete catalytic cracking operation can be set up on a small scale to evaluate catalysts and operating conditions before going to a larger scale. If the miniature equipment is used on a process where scale-up factors are known, where product specifications are well defined, and where the market is understood, it may be possible to omit any larger pilot operations.

Project evaluation

When it becomes evident that a pilot plant operation is to be proposed, a Project Evaluation is in order. A pilot plant is normally proposed when entering Stage III or Stage IV, but occasionally the proposal may occur earlier. This evaluation is a short write-up by the originating laboratory group, using information developed in the stage system to answer the following questions:

I. Brief description.
   1. What is the project (product and process)?
   2. Purpose and need?
   3. What alternative processes have been studied for producing this product?

II. Research problems (market problems answered in VI below).
   1. What major problems remain?
   2. Probability of technical success? What are the chances that a successful plant design will be achieved with only the normal amount of start-up troubles?

III. Production plant.
   1. Initial size?
   2. Assumed completion date?

. . . two distinctly different methods for estimating profit possibilities of a project are presented in detail here.

3. Assumed cost, capital, return figures?

IV. Future research & sales development costs (list capital expenditures separately).
1. How much will research spend each year from now until the production plant is completed? What manpower will be needed for this program?
2. How much will the sales development group spend each year from now until the initial production is completed? What manpower will be needed for this program?
3. After the plant is completed, what per cent of plant sales will be required for additional research? For additional work by the sales development groups?

V. Patents.
1. What is the patent situation? Compound, process, uses.

VI. Market & use information.
1. What is the competition?
(a) Products?
(b) Processes?
2. Advantages and disadvantages of product and process?
3. Price at which customer has economic justification for use?
4. Projected sales price when the first plant is completed?
5. Market for ten-year period after the first plant is completed?
(a) Entire market?
(b) Company share?
(c) Selling price, relation of price to volume?
(d) Probability that company will have this market at this price?
6. To what other potential uses could this product be adapted for further expansion of its market?
7. How does it fit into the company manufacturing operations relationships?

Questions I, II, and part of IV are answered by the laboratory group's own authority. The economics, patent, market, and sales development questions require information obtained from the corresponding independent departments.

The completed project evaluation is made available to interested management and to heads of all related and consulting departments. In this way any disagreements on definition of problems are brought out, and commitments of assistance are secured from departments which will be involved in a key manner later.

Economics *(6)*

There are two distinctly different methods for estimating profit possibilities of a project.

1. Research value. One, research value, is for projects in stages I, II, and III. One man in each laboratory is trained to use this method. He is kept up to date on the proper cost figures by our Central Economic Evaluation Department. The computation of the research value is based on a preliminary capital investment estimate, and on purchase price or precalculated values for raw materials and utilities. These values contain a built-in return on capital. Several levels of direct capital for the new product are figured, as are several plant capacities. The importance of yields from raw materials is also computed.

The object of a research value study is to see if the project goal is worthwhile. It is long range and optimistic in respect to attainment of technical accomplishment. It is not necessary to relate to actual locations, present book costs, current raw material situations, or existing equipment. It must be replaced later by a study of the actual situation.

The research value figure does not set a selling price, but it does contribute materially to planning a pilot plant operation by displaying the relative importance of the various factors in costs and profits. The factors of significance can be selected for intensive research.

2. Specific economics. The second economic procedure is used when a specific pilot plant is proposed. It includes study of a projected production plant. A site and a capacity are chosen. An estimate of direct and other capital investment is made. Operating cost is calculated, based on actual raw material costs, and on yields which can reasonably be expected from attained results. This estimate is made by the central Economic Evaluation Department based on a design prepared by engineers in cooperation with the originating laboratory.

A selling price is set by the Pricing Department. Then the return on investment is figured .

Such a definite and detailed design and estimate for a projected production plant is made whenever a pilot plant is proposed. Specific economic study should show that a profit can

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Figure 2. A multiproduct pilot plant.

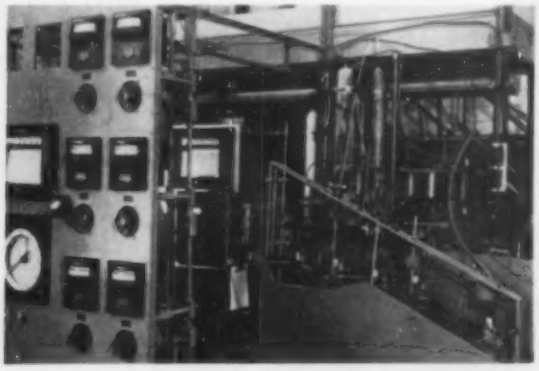

Figure 3. A "miniplant."

Pilot plant

continued

be expected from the production plant which will follow if the pilot plant operation is successful. Such calculations are not made on the pilot plant itself, because such a unit is not normally expected to earn a profit. Specific economics, of course, sometimes show that a project is not ready for pilot planting. A vital contribution to the pilot plant program is the list of process engineering questions which develop in the course of the design.

Investigation plan for pilot plant

A plan for conducting investigations in the pilot plant should be developed. The specific problems to be solved should be stated, with plans for the methods to be used in obtaining solutions. The plan should be flexible, and no more detailed than is necessary to outline general principles.

Advice, assistance, and review of plans should be obtained from any other engineers who have specialized skills related to the problems at hand. Design engineers from the Main Engineering Department, production men who will operate the final plant, engineers skilled in machine computation, and marketing specialists may contribute simplifications in process, in methods of answering questions, or in clarification of product specifications.

Market goals

The Market Goals are estimates of the need for product from the pilot plant, and of the probable market for the product from the production plant.

Estimates are cooperative. The quantities involved are only vaguely defined for use in the stage system. A project evaluation calls for brief statements on the probable volume under specified conditions. A definite statement must be given to develop the investigation plan for the pilot plant. The goals to be specified are: (1) rate of production desired, (2) starting date and duration of production, and (3) general specifications of product.

Five separate product departments (Agricultural Chemicals, Chemicals, Magnesium, Plastics, and Textiles) cover business and sales development aspects so as to include all of the company's products. A Market Research department is available to make studies in any field at any stage.

A research group can secure the opinion and cooperation of these departments by consultation. Customer contacting or laboratory work on applications will be done by these departments in the spirit of a member of the project team. Use of the methods described in this paper makes sure that cooperation is requested at a stage early enough to be effective.

Patents

A letter from the Patent Department is needed to explain the position in respect to protection and possible limitations, and to suggest information which should be obtained. The timing of the letter is dependent on the judgment of the laboratory and the Patent Department.

Authorization request

Since each project presented is somewhat different from any other, there is variation in how the methods described in this article apply to any particular case. The initiative in applying the methods lies with the research group who are developing the project. By participating in all decisions they can plan with confidence. A review of the application of the methods takes place in the office of the company director of research at the time an authorization request is submitted. The review may call attention to alternate methods of doing the job, through use of existing facilities in other departments or other locations. This review also aids in preparing a complete and current story to submit to management for approval. The story should include an up-to-date project evaluation, an investigation plan, and a form. The form identifies the project, lists immediate requirements for funds and people, gives the estimated time schedule, and contains the check list in Table 1.

Each Consulting Department, except under item 1, approves only its area of interest, not the project as a whole.

Items *2*, *4*, *5*, *7*, and *12* have been explained previously.

1. In each of the five product departments is a department research director. His approval of the project as a whole is essential. Use of the stage system and of the project evaluation has kept him informed as the project progressed.

3. If the proposal is for a product which definitely will be assigned to a particular plant superintendent, his approval should be obtained.

6. The Production Control Department should be consulted on questions of available plant capacity for raw materials and for ability to utilize by-products. Production control can also bring in the Purchasing Department for advice on purchased raw materials.

8. The Safety Department must have an opportunity to enter any suggestions.

9. The Biochemical Research Laboratory handles questions of toxicology and industrial hygiene. Their recommendations are frequently required.

10. When wastes are involved, the decisions on their disposal require participation by Waste Disposal Department.

11. Review here is necessary for purposes of cost and property accounting.

This same procedure, with minor differences in supplementary information is followed for authorization of capital projects or of operating expenses.

Authorization Request Check List

Table 1

Consulting Departments:	Omitted	Approved	Dissent	Date	Initials
1. Product Dept. Research Dir.					
2. Engineering Department					
3. Plant Superintendent					
4. Sales Development					
5. Economic Evaluation					
6. Production Control					
7. Patent					
8. Safety					
9. Biochemical Laboratory					
10. Waste Disposal					
11. Accounting					
12. Computations Laboratory					

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Presented at A.I.Ch.E. meeting, Chicago, Ill.

Air pollution effects of IRRADIATED AUTO EXHAUST as related to fuel composition

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Edward A. Schuck
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In Los Angeles, air pollution is characterized by increased concentrations of oxidant, now known to be principally ozone, by the formation of an aerosol haze even at quite low levels of relative humidity, by the development of eye irritation, and by the occurrence of damage to vegetation with characteristic symptoms. The demonstration, in 1956 and 1957, that both eye irritant and aerosol are formed along with ozone when diluted auto exhaust is irradiated was a major factor in the indictment of auto exhaust.

Since the traces of hydrocarbon present in exhaust appeared to play a critical role, the suggestion has frequently been made that some alternative motor fuel might be used which would produce a less reactive exhaust. Proposed fuels range from liquid petroleum gas to catalytically reformed gasolines. There is no indication that the use of any of these fuels would substantially reduce the total *amount* of hydrocarbon emitted; it could only affect the types of hydrocarbons emitted. Mader and Chambers (*1*) suggested that the use of catalytically reformed fuel (containing aromatics) in place of gasolines currently in use would produce an exhaust which was less reactive and therefore less objectionable. Data presented by Richards (*2*), however, indicated that the composition of the hydrocarbon portion of the exhaust was essentially independent of the composition of the fuel. Each of these investigators relied partly on analysis of the hydrocarbon portion of the exhaust and partly on results of irradiation of the exhaust to arrive at a different conclusion.

The facility for the irradiation and study of diluted auto exhaust, developed at the Southern California Laboratories of the Stanford Research Institute under the sponsorship of the Air Pollution Foundation, is well suited for a study of this problem. With the addition of the Franklin Institute's Mobile Air Pollution Laboratory, which houses long-path infrared equipment (*3, 4*), it was possible to study a considerable number of features of this problem simultaneously. The present paper gives the results of such a study carried out from June, 1957, to June, 1958, under the joint sponsorship of the Air Pollution Foundation and the Smoke and Fumes Committee of the American Petroleum Institute. This study was designed to compare air pollution manifestations developed by irradiating the exhausts from test fuels, and was not aimed at establishing either the chemical nature or the mode of formation of either the eye irritant or the aerosol.

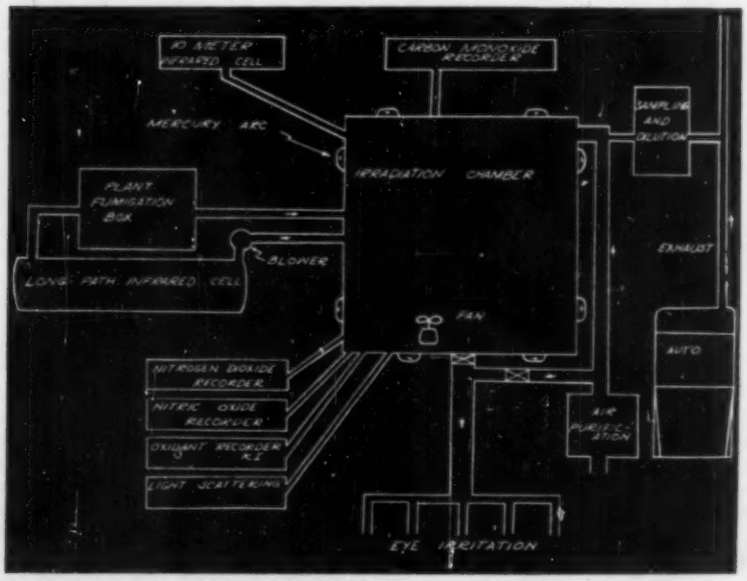

Figure 1. Apparatus for auto exhaust studies.

Exhaust sampling and irradiation

Exhaust was obtained from a car mounted on a chassis dynamometer which was capable of simulating both the road load encountered during cruising and the car's inertia during acceleration and deceleration. The car was continuously driven by a cam mechanism through a cycle simulating idling, acceleration, cruising, and deceleration. The exhaust gas sample was diluted in two stages with purified air, then metered into the irradiation chamber (Figure 1).

The irradiation chamber itself had a volume of about 520 cu. ft. and was equipped with twenty-four 400-watt H4 mercury arcs and seventy-eight Blacklite fluorescent bulbs to provide artificial sunlight. The mixture was cooled and stirred. Further details may be found (*5*).

Eye irritation and aerosol

Eye irritation and aerosol were measured on the contents of the chamber along with a wide variety of chemical characteristics. Eye irrita-

continued

tion was judged by panels of ten male college students. As shown in Figure 1, samples of irradiated exhaust were passed to five booths equipped with plastic face masks. Each panel of ten was divided into two groups, and each of the five individuals in each group was exposed to the test mixture for two 5-min. periods. Therefore, about 25 min. were required to obtain one measurement of eye irritation. Each subject recorded his judgment of the eye irritation every 30 sec. as none, light, medium, or severe. The eye irritation index was computed by giving a number (none = 0, light = 1, medium = 2, severe = 3) to the highest irritation reported by each individual during one exposure. These numbers were then totaled to give an index for this exposure. The entire panel of ten subjects was then exposed again and a second index calculated in the same way. These two values were then averaged and normalized to eight subjects to give the final eye irritation index. If each of the ten subjects reported a maximum of severe irritation (three points), this would be an index of 24 (i. e., $3 \times 10 \times (8/10) = 24$).

Aerosol was measured with a 90 degree light-scattering photometer patterned after that used by O'Konski and Doyle (*6*). The amount of aerosol was expressed as the ratio of the light scattered at 90 degrees by the sample to that scattered by an equal volume of particle-free air.

Analytical methods

A long-path infrared absorption cell (path length of 240 in.) was used to estimate the concentration of a number of compounds of interest at concentrations below 1 p.p.m. These include ozone, aldehyde, peroxyacyl nitrite, ethylene, and acetylene.

A 10-m. multiple reflection infrared absorption cell was used to measure total hydrocarbon. Carbon monoxide concentration in the chamber was measured with a Mine Safety Appliances nondispersive infrared analyzer. A dual recording colorimeter based on Saltzman's reagent (*7*) was used to monitor nitric oxide and nitric oxide plus nitrogen dioxide. Gas chromatographic equipment was used to analyze the hydrocarbon content of the exhaust both before and after dilution as well as after irradiation.

Test fuels

The fuels chosen for study can be described as follows: Fuel No. 1 was a blend of gasolines being sold in the Los Angeles area in the proportion in which they are sold; Fuel No. 2 (used only in the first group of experiments) was an aromatic fuel containing large amounts of benzene and toluene and some catalytic reformate but no olefin; Fuel No. 2a was also an aromatic fuel but contained a larger proportion of catalytic reformate; Fuel No. 3 was a blend of cracked stocks with a high olefin content; Fuel No. 4 was a paraffinic fuel containing a large portion of isooctane and little olefin or aromatic.

All fuels contained light paraffins to attain a full boiling range. Characteristics of the test fuels are summarized in Table 1. Both the fuels themselves and the data given in the table were obtained through the cooperation of the Western Oil and Gas Association.

The lead contents of the fuels were adjusted to be approximately the same, but no effort was made to control or to adjust the sulfur content or the octane ratings.

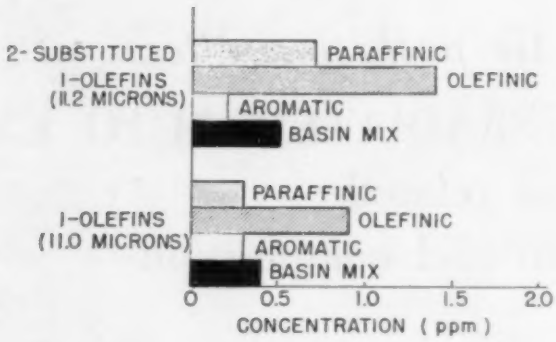

Figure 2. Olefins in exhaust samples from four fuels (measured by infrared).

The cars

Four cars were used during the course of this program. They are described briefly in Table 2.

Each car was equipped with new plugs and points and was lubricated and tuned before test but was not otherwise serviced. Some experiments were made on the carburetor of Car C during the course of which a new carburetor was installed. This did not make an appreciable difference in the exhaust hydrocarbon content, so the new carburetor was used throughout the test.

Exhaust composition and driving cycle

The exhaust components of interest are trace amounts of hydrocarbons and nitrogen oxides. Most of the combined nitrogen is present as nitric oxide which is formed by fixation in the engine when it is operated under load. Hydrocarbons are emitted in the highest concentration under no load

Table 1. Fuel Characteristics

Test fuel no.	1	2	2a	3	4
Description	L.A. basin mixed gasoline	Aromatic fuel	Aromatic fuel	Olefinic fuel	Paraffinic fuel
Gravity, °API	57.2	51.0	56.7	57.4	67.0
Vap. Pres. Reid, lb at 100°F	8.4	8.1	9.0	9.0	8.3
TEL, ml/gal	2.07	1.84	2.03	2.10	1.97
ASTM Distillation, °F					
IBP	98	96	96	99	102
10%	136	133	140	127	145
50%	232	245	236	205	234
90%	348	346	354	379	355
EP	401	404	416	418	392
Recovery, %v	98.0	98.0	98.0	98.0	97.0
Octane numbers					
Research	94.1	98.6	94.9	98.0	93.5
Motor	83.9	90.2	88.8	84.7	92.5
Sulfur, %w	0.1	0.024	0.01	0.22	0.04
Gum, mg/100 ml	0.6	1.0	1.0	2.0	...
Hydrocarbon composition					
Saturates, %	62.2	68.0	66.0	24.0	97.0
Aromatics, %	21.9	32.0	33.5	24.0	3.0
Olefins, %	15.9	0.0	0.5	52.0	0.0

conditions. The choice of driving conditions is important because it determines not only the relative amounts of nitric oxide and hydrocarbon in the sample but may also influence the relative amounts of hydrocarbons of different types. These, in turn, have a profound influence on the behavior of the exhaust under irradiation.

It was necessary to proceed with some arbitrariness in the choice of sampling procedures. The principal guide used was the Traffic Pattern Survey conducted by the Automobile Manufacturers Association (8). This survey arrived at the average distribution of time spent in the various modes of car operation.

Analysis of unirradiated exhaust showed that nitric oxide predominated over nitrogen dioxide by a large margin. The long-path infrared equipment showed hydrocarbon, carbon monoxide, olefins (ethylene and higher members), and acetylene. No oxygenated materials were detected in the unirradiated exhaust samples. Aldehydes were undetectable in the dark samples but were producted in quantity by irradiation. There were no unidentified bands in the spectrum of the unirradiated exhaust.

Although the amount of ethylene present in the unirradiated exhaust was comparable for all four fuels, distinct differences in the concentrations of higher olefins were observed, depending on the fuel. These are summarized in Figure 2, which shows results obtained on the diluted exhaust from Car A sampled in the volume ratio of 1 part idling, 7 parts acceleration, 18 parts cruising, 9 parts deceleration. It is noteworthy that the two nonolefinic fuels produced exhausts containing different amounts of olefin. These exhaust samples also showed different amounts of aromatics, depending on the fuel being burned. The paraffinic fuel exhaust showed virtually no aromatic absorption at 3.3μ where the aromatic fuel exhaust showed strong absorption, and the exhausts from the other two fuels were intermediate, in accordance with the aromatic content of the fuels.

Gas chromatographic analysis of the hydrocarbon portion of the exhaust both before and after dilution verified and clarified these observations. Such analysis revealed that the exhaust contained two types of hydrocarbons: (1) unchanged gasoline and (2) two to four carbon unsaturates, the smaller molecules being present in larger concentration. The greater olefin concentration in the exhaust from the paraffinic fuel, as compared with

continued on next page

Table 2 Car characteristics

Car	Yr.	Carburetor	Stated hp.	Stated compression ratio	Indicated mileage
A	1954	Two Bore	150	7.5/1	59,000
B	1955	Two Bore	162	7.6/1	22,000
C	1956	Four Bore	205	9.25/1	34,000
D	1956	Two Bore	220	8.9/1	48,000

All cars had V-8 engines and automatic transmissions.

Table 3. Chemical Behavior of Exhaust Samples: Static-Dynamic Experiments

Fuel	Mixture†	Hydrocarbon before irrad. (p.p.m.)	Lag time* (minutes)	Rate‡ (p.p.hm/min)	Peak concentrations (p.p.m.) Ozone	Aldehyde	PAN**
Car A. 2500 p.p.m. exhaust							
Basin mix	1:22:6:6	1.7	48	1.4	0.8	1.3	0.4
	1:25:6:3	1.9	50	1.8	1.0	..	..
Aromatic	1:22:6:6	2.0	60	1.3	1.0	1.0	0.6
	1:25:6:3	1.4	60	1.0	1.0	..	..
Olefinic	1:22:6:6	1.7	20	3.8	1.0	2.6	0.7
	1:25:6:3	1.6	25	2.7	0.9	..	..
Paraffinic	1:22:6:6	3.3	50	1.6	1.0	1.8	0.4
	1:25:6:3	2.2	75	1.3	0.9	..	..
Car B. 2500 p.p.m. exhaust							
Basin mix	1:22:6:6	2.0	56	..	0.7	1.6	0.5
	1:25:6:3	1.5	120	1.7	..	..	..
Aromatic	1:22:6:6	1.6	115	1.7	0.8	1.2	0.5
	1:25:6:3	1.6	100	1.1	0.8	..	..
Olefinic	1:22:6:6	1.3	38	4.2	0.9	2.1	0.8
	1:25:6:3	1.0	38	2.2	0.8	..	..
Paraffinic	1:22:6:6	1.5	85	1.8	0.8	1.3	0.4
	1:25:6:3	1.3	120	1.3	..	..	..
Car B. (enriched carbureter) 2900 p.p.m. exhaust							
Basin mix	1:22:6:6	3.6	42	3.5	1.0	2.5	0.8
		4.2	28	4.9	1.0	2.8	0.7
Aromatic		2.3	45	3.5	1.0	2.3	0.8
		4.4	65	2.3	0.9	2.3	0.6
Olefinic		3.1	18	6.0	1.1	3.2	1.1
		3.7	18	6.6	0.9	3.6	1.1
Paraffinic		..	40	2.6	1.2	3.3	0.6
		5.2	33	3.2	0.9	2.5	0.5
Car C. (enriched carbureter) 4000 p.p.m. exhaust							
Basin mix	1:22:6:6	4.2	30	5.0	0.9	3.5	0.9
		4.8	30	5.4	0.8	3.0	0.7
Aromatic		3.4	45	4.3	0.6	3.1	0.6
		5.6	43	2.5	0.8	2.2	0.6
Olefinic		3.5	18	6.3	0.6	3.7	1.1
		3.3	20	6.2	..	..	..
Paraffinic		5.1	30	3.2	0.6	3.0	0.4
		6.4	36	3.9	0.8	2.9	0.3

† *Relative volumes: idling, acceleration, cruising, deceleration exhausts.*

* *Time to NO_2 peak and ozone appearance.*

‡ *Initial rate of NO_2 formation; i.e., peak NO_2 concentration/lag time.*

** *Peroxyacetyl nitrite.*

the aromatic fuel, was explained by the larger concentration of three and four carbon olefins in this exhaust.

Unirradiated exhaust contained a small amount of particulate matter which produced a signal on the light-scattering photometer. This aerosol disappears at a moderate rate (half-life about 1½ hr.) when the chamber contents are stirred without irradiation or addition of fresh exhaust. This disappearance was the only detectable change in the reaction mixture in the dark.

Procedure

The chamber was operated both dynamically (stirred-flow reactor) and statically. For dynamic experiments the chamber was charged in the dark. After reaching steady state, the ultraviolet lights were turned on and the flow rate was adjusted to maintain the desired concentration. Residence time is defined as the volume of the chamber divided by the rate of flow of diluted exhaust. For static experiments the chamber was again charged in the dark, but when the desired concentration was reached, the intake and outlet were closed off. The reaction mixture was monitored during irradiation with all the instruments except the carbon monoxide recorder and the eye irritation panels.

In order to measure eye irritation on a statically irradiated sample, it was necessary to displace a sample from the chamber with either purified air or additional diluted exhaust. Displacement of a statically irradiated sample from the chamber with diluted exhaust, while leaving the ultraviolet lamps on, resulted in a combination static-dynamic experiment. A large group of experiments was carried out with this scheme which is illustrated in Figure 3. After a 4-hr. static irradiation of the initial charge, the flow of diluted exhaust was resumed without turning off the arcs. Simultaneously the first panel of eye irritation subjects was exposed. Additional panels of subjects were exposed after 1 hr. and after 2½ hr. of dynamic irradiation (see Figure 3). For this type of experiment an effective residence time (R_{eff}) can be derived:

$$R_{eff} = R + (t_o - R)\, exp\,(-t/R)$$

where R = dynamic residence time (volume/flow rate); t_o = initial static reaction time; t = time after starting dynamic portion of the experiment. Effective residence times for the three panels were, therefore, 3.4, 1.9, and 1.1 hr.

Figure 3, although not a quantitative description, serves to illustrate a typical experiment. The first process

Table 4. Eye Irritation From Irradiated Auto-Exhaust

(Four experiments with irradiated purified air gave an average eye irritation index of 2.3. Maximum possible index = 24)

	Fuel: Basin mix	Aromatic	Olefinic	Paraffinic
A) Comparison of four fuels and four cars				
Average index for two static-dynamic experiments (with three panels); one with each exhaust mixture†: 1:22:6:6 and 1:25:6:3; 2500 p.p.m.				
CAR A	6.3	4.3	9.8	5.4
CAR B	5.4	5.5	9.2	5.5
CAR C	3.9	3.5	5.3	3.4
CAR D	3.2	2.6	4.4	5.4
B) Comparison of four fuels and two cars with enriched carburetors				
Average index for two static-dynamic experiments (with three panels); mixture†: 1:22:6:6.				
CAR B (2900 p.p.m.)	11.4	10.4	17.4	9.3
CAR C (4000 p.p.m.)	11.9	10.4	17.9	9.9
Average index for three panels in one dynamic experiment; mixture†: 1:22:6:6.				
CAR B (2900 p.p.m.)	16.0	9.7	18.9	10.6
CAR C (4000 p.p.m.)	14.4	6.8	16.4	11.0
C) Comparison with excess deceleration exhaust				
Average index for three panels in one static-dynamic experiment. Car B with 2900 p.p.m.; mixture†: 1:6:13:15.	13.3	10.8	13.7	9.9
D) Dynamic experiments with lower light intensity				
Average index for one panel in four dynamic experiments. Car A with 2500 p.p.m.; mixture†: 1:7:18:9; 24 H4 mercury arcs.	15	9*	18	6

† *Relative volumes: idling, acceleration, cruising, deceleration exhausts.*
* *Fuel No. 2 rather than No. 2a was used in this series.*

which occurred when the arcs were turned on was the conversion of nitric oxide to nitrogen dioxide. When the nitrogen dioxide reached its peak value, ozone appeared in the mixture and increased to a maximum value. This correspondence between the peak nitrogen dioxide concentration and the time of appearance of ozone was repeatedly observed. This time was defined as the lag time, and varied from a few minutes to as much as 2 hr. The nitrogen dioxide disappeared on continued irradiation while peroxyacyl nitrite gradually increased in concentration. Aldehyde also accumulated in the mixture during this 4-hr. static irradiation. Total hydrocarbon, as measured by the CH absorption, decreased somewhat during irradiation. When the dynamic portion of the experiment was begun, the ozone concentration dropped to a low value and the nitrogen dioxide increased to an intermediate value.

Experiments were carried out in groups each of which was statistically designed to study a single phase of the problem. The first three groups of sixteen experiments each were done with Car A, and the variables explored included: irradiation time, static vs. dynamic methods, exhaust concentrations, and driving cycle (actually relative volumes of sample taken from each mode of operation). The next group of experiments involved comparison of the exhaust from all four cars with the static-dynamic irradiation scheme and a more restricted variation in exhaust concentration and driving cycle. A final group was then done with Cars B and C with somewhat enriched carburetor settings so that more hydrocarbon was emitted in the exhaust. The four test fuels were used in all groups of experiments.

Chemical behavior

Qualitatively, all exhaust samples reacted in the manner illustrated in Figure 3. There were differences, however, in the rate and extent of reaction. The rate of formation of nitrogen dioxide was used as a measure of the rate of reaction. It was obtained by dividing the maximum nitrogen dioxide concentration by the time required to attain this

peak. This time is the same as the lag time before the appearance of ozone, as illustrated in Figure 3. These measurements are given in Table 3 along with peak concentrations of ozone, aldehyde, and peroxyacetyl nitrite (the first member of the series) (3,4), as measured for several groups of experiments. The olefinic fuel exhaust consistently reacted more rapidly than the others, but the peak ozone concentration was substantially the same for all types of exhaust. Exhaust from the olefinic fuel also produced aldehyde and peroxyacetyl nitrite more rapidly than the other three types of exhaust. Other types of oxygenated compounds were not detected; for example, primary alcohols were less than 0.2 p.p.m. judging by the lack of absorption at 9.5-9.6 μ. There was evidence of the formic acid band at 9.06 μ after prolonged irradiation, but this compound was not a major reaction product. There were also indications of the formation of acetone.

Gas chromatographic analysis showed that the C_3 olefins were completely consumed by 2 hr. of irradiation while the smaller olefins reacted more slowly; about half the ethylene remained after 2 hr. Saturates also reacted, but more slowly.

Eye irritation

Significant eye irritation could be developed by irradiating the exhaust from each fuel studied. Previous studies had indicated that the eye irritant was formed quickly in the mixture and had a half-life of many hours in the dark (*9*). This indicated that the eye irritant is a stable material rather than a free radical or other transitory intermediate. Data on eye irritation are summarized in Table 4. Section A of this table summarizes the eye irritation data obtained with the four fuels and four cars using 2500 p.p.m. of exhaust and two exhaust ratios. The first of the ratios was the one arrived at by the AMA survey already mentioned (*8*); the second ratio was somewhat richer in deceleration exhaust.

To compare eye irritation as a function of fuel type, it was necessary to increase the level of irritation by raising the hydrocarbon concentration in the exhaust samples. This was done by (1) increasing the exhaust concentration; (2) adjusting the carburetor to provide a richer mixture; and (3) sampling a larger proportion of deceleration exhaust (Section B, Table 4). To obtain a richer air-fuel ratio, the largest fuel jets specified by the manufacturer were used and the idle jets were opened to the maximum

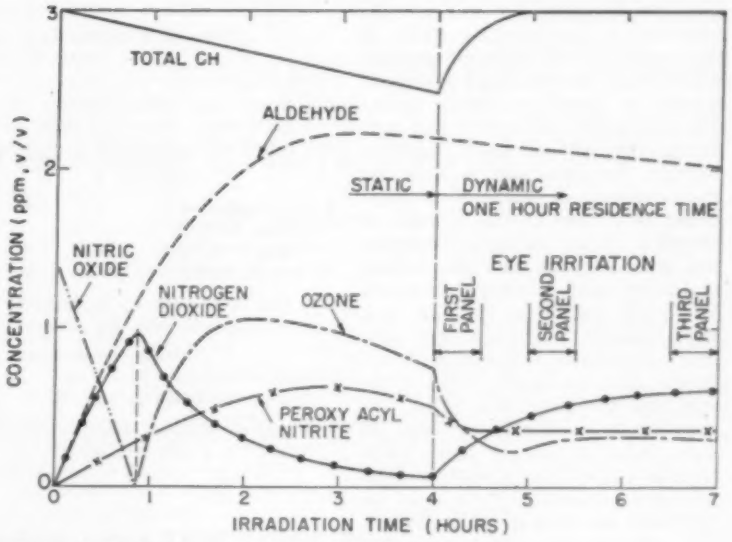

Figure 3. Illustration of static-dynamic photolysis.

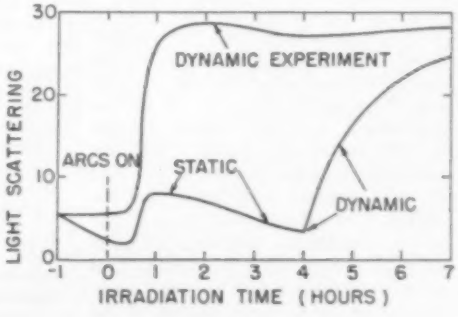

Figure 4. Contrasting behavior in static-dynamic experiments.

within specifications. After modification of the carburetors, Car C produced less hydrocarbon than Car B so that use of a higher exhaust concentration from Car C resulted in comparable eye irritation indices. Data of Table 4, Sections A and B, were treated by analysis of variance to see if an effect of fuel on eye irritation was present. The results show an effect of *fuel*, *residence time*, and *car* on eye irritation, significant at the 99% level. No significant effect of *exhaust ratio* on eye irritation was detected at the 95% significance level. Further analyses showed that the fuel difference was associated with the olefinic fuel. The other three fuels were not different from one another at the 95% significance level.

Sections C and D of Table 4 report data obtained under different conditions of operation. In Section C comparable levels of eye irritation were obtained with a mixture containing a large proportion of deceleration exhaust in a limited series of experiments. Section D reports irritation in a series of dynamic experiments in which only the 24 mercury arcs were used for irradiation. Since this was the first group of experiments performed, the original aromatic fuel (No. 2) was used in this series. Statistical comparison showed that the only difference between fuels which was not significant at the 95% level was that between the aromatic and paraffinic fuels. Differences at the 99% level were found between the following pairs of fuels: Basin mix and paraffinic, aromatic and olefinic, olefinic and paraffinic. The lower level of irradiation and the shorter reaction time (1 hr. dynamic) probably tended to favor the exhaust samples which react more rapidly (olefinic and Basin mix) as compared with the experiments reported in Sections A and B.

Aerosol

As previously stated, unirradiated auto exhaust contains some particulate matter which will scatter light. When diluted exhaust is stirred, this

continued

material disappears, presumably by collection on the interior surfaces of the irradiation chamber. When irradiated with ultraviolet, an additional amount of aerosol sometimes forms. The amount of light-scattering then increases to a maximum. Distinctly different behavior was observed in static-dynamic experiments as illustrated in Figure 4. The amount of aerosol produced by static irradiation was invariably less than that formed in a comparable dynamic experiment. The level reached at the end of a static-dynamic irradiation was generally comparable to that reached in a similar dynamic experiment. An initial light-scattering value of five corresponds to a visibility of about 48 miles, while a value of thirty corresponds to about 8-mile visibility. Data on aerosol formation in dynamic experiments are summarized in Table 5. The exhaust from the olefinic fuel consistently produced more aerosol than the exhaust from the other fuels, while that produced by the exhaust from the paraffinic fuel was insignificant. The exhaust from the Basin mix fuel produced considerable aerosol, and the aromatic fuel exhaust gave a measurable but quite small increase in light scattering. Aerosol results on the static-dynamic irradiations (Table 6) are consistent with this in that the olefinic fuel exhaust was the only one which consistently produced an aerosol peak during static irradiation. This exhaust also produced the most aerosol during the dynamic portion of the experiments. The amounts of aerosol produced by the other three fuels were insignificant.

In the four-car study for which eye irritation values are given in Table 4 (Section A), irradiation of exhaust caused a detectable increase in aerosol in only one experiment (Car A; olefinic fuel).

There are several peculiarities in the behavior of exhaust in respect to aerosol formation. In the first place, there appears to be a delay in the appearance of aerosol after turning on the ultraviolet lights. This might be attributed to a delay in nucleation and growth of the particles. However, it was previously observed that a transient peak in the concentration of condensation nuclei coincided with the onset of aerosol formation *(9, 10)*. It therefore appears that conditions for aerosol formation are quite transient. This may also be related to the puzzling difference in aerosol formation between otherwise comparable static and dynamic experiments. It will be noted that aerosol-forming ability of the various fuels follows both their olefin content and their sulfur content (compare Tables 5 and 6 with Table 1).

Another observation which can be made is that many experiments which produced significant eye irritation failed to produce aerosol. No direct relationship between eye irritation and particulate matter was found.

Table 5. Aerosol Formation in Dynamic Experiments
Ratio of 90-degree light scattering by exhaust samples to scattering by particle-free air

A) Both cars with enriched carburetors; mixture†: 1:22:6:6. Car B at 2900 p.p.m.; Car C at 4000 p.p.m.

Fuel:	Basin mix		Aromatic		Olefinic		Paraffinic	
Car:	B	C	B	C	B	C	B	C
Before irradiation	7.5	7.9	7.0	4.2	5.7	3.9	4.0	5.8
Maximum increase during irradiation	19.5	8.4	1.0	1.5	24.3	8.6	0	0
At end of irradiation	23.0	11.8	6.5	6.5	28.0	10.8	3.0	2.9

B) Car A at 2500 p.p.m.; mixture†: 1:7:18:9. Irradiation with 24 mercury arcs only.

Fuel:	Basin mix	Aromatic*	Olefinic	Paraffinic
Maximum increase during irradiation	39	5	56	2

† *Relative volumes: idling, acceleration, cruising, deceleration exhausts.*
* *Fuel No. 2 (not No. 2a).*

Table 6. Aerosol Formation in Static-Dynamic Experiments
Ratio of 90-degree light scattering by exhaust samples to scattering by particle-free air

Mixture†: 1:22:6:6.

Fuel:	Basin mix		Aromatic		Olefinic		Paraffinic	
Car B (enriched carburetor) 2900 p.p.m.								
Before irradiation	4.0	3.8	2.7	1.7	4.0	4.8	2.3	0
Maximum increase during static irradiation	0	0	0	0.9	5.2	1.8	0	0
At end of dynamic irradiation	0	9.5	3.8	4.9	35.0	20.0	5.4	4.8
Car C (enriched carburetor) 4000 p.p.m.								
Before irradiation	6.5	4.3	2.0	7.1	2.9	3.0	4.5	3.2
Maximum increase during static irradiation	0.6	0	0	0	2.3	5.7	0	0
At end of dynamic irradiation	12.0	7.3	4.3	4.2	14.7	14.5	5.2	4.1

† *Relative volumes: idling, acceleration, cruising, deceleration exhausts.*

Plant damage

During a number of the experiments reported here, pinto bean plants, endive, and petunias were exposed to various samples of irradiated exhaust in the exposure box shown in Figure 1. Test plants were supplied by the Air Pollution Research Group at the University of California, Riverside. The intent was to compare the damage *(11)* produced by the different exhaust samples just as the eye irritation and aerosol were compared. However, no more than traces of the "oxidant" type of plant damage were ever obtained, amounts entirely inadequate for the comparison of exhausts from the different fuels.

Artificial sunlight irradiation of the exhaust from any of four test fuels resulted in the formation of ozone and the development of substantial eye irritation. The exhaust from a paraffinic, sulfur-free fuel failed to produce aerosol when irradiated under conditions which did produce aerosol with exhausts from fuels containing both olefin and sulfur.

The exhaust from the olefinic fuel reacted more rapidly under irradiation than the exhaust from the other three test fuels. This was indicated by an increased rate of formation of nitrogen dioxide, a shorter lag time for the

appearance of ozone, and a more rapid formation of aldehyde and peroxyacyl nitrite. The peak ozone concentration formed by irradiating the exhaust was independent of the fuel type.

The exhaust from the olefinic fuel produced more eye irritation than that from the other three fuels which were comparable in this respect.

Individual automobiles varied quite markedly in the extent to which their exhausts produced air pollution effects. This correlated with the variations in amount of hydrocarbon emitted in the exhaust which could be increased, with a corresponding increase in air pollution effects, by enriching the mixture fed to the engine.

Conclusion

Results of these experiments indicate that replacement of the present Basin mix (15% olefin) with nonolefinic fuels would not markedly reduce eye irritation from automobile exhaust. However, replacement with a high olefinic (*ca.* 50%) fuel would increase eye irritation.

Since the peak ozone values were independent of the type of fuel used, ozone levels in the Los Angeles area would not be affected by a change in fuel composition.

That portion of the atmospheric aerosol produced photochemically from automobile exhaust would be decreased by use of a low-olefin, low-sulfur fuel.

Eye irritation, visibility reduction, and ozone formation are affected as much by differences in automobiles as by differences in fuel composition.

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preliminary design studies of

Low temperature refrigeration plants-Part I

David Aronson
Worthington Corp., Harrison, New Jersey

Refrigeration for the liquefaction of gases such as methane, air, hydrogen, and helium is expensive both in terms of equipment and horsepower per ton of refrigeration. Consequently, a thorough analysis of the refrigeration process is warranted to make certain that cycle conditions selected are reasonably close to optimum.

There are many ways of analyzing refrigeration cycles, the merit of any one method depending on the purpose of the study and the taste of the individual or group making the study. The approach here shows how performance of each piece of equipment affects over-all cycle performance. In Parts I-III *(1)*, the method developed consisted essentially of comparing the performance of the actual cycle with the performance of an ideal Claude cycle, on the assumption of ideal gas properties for the working fluid in both. Since helium at low pressure acts almost like an ideal gas, its properties are used in the calculation of cycle performance, thus affording realistic examples for comparison. Several cycles are worked out in which commercially acceptable efficiencies are employed for the components, compressors, expanders, and heat exchangers. The power requirement of the ideal cycle, having components of 100% efficiency, is compared with the power requirement of an actual cycle with commercially obtainable components.

This method is most convenient for studying cycles using expanders as the sole means of obtaining a refrigerating effect. But it is a rather unwieldy procedure for analyzing cycles using the Joule-Thomson effect of nonideal gases, or using liquefaction (condensation) and expansion of the resulting condensate in one or more stages of the refrigeration process. The latter types of refrigeration systems operating down to about −150°F. have been treated extensively in the literature. Recently a number of papers (*2, 3, 4,* and *5*) have appeared which consider the design, analysis, and operation of such refrigeration systems down to much lower temperatures.

Part IV discusses this subject from a viewpoint similar to that taken in Parts I-III, except that it goes beyond the Claude or "dense air" cycle of Parts I-III and embraces most of the other heat-power process cycles which have been developed over the past century or more.

Cycle classifications

The thoughts expressed here constitute a restatement of what has been adequately stated in the past. The physicist, the physical chemist, and the thermodynamicist will find this presentation somewhat simple and naive, yet it is quite probable that the material will prove helpful to those engaged in the design of what is now popularly termed "hardware."

Thermodynamics does not offer any fundamental distinction between cycles for the production of power and cycles for refrigeration. Since many engineers have studied power cycles in as much or greater detail than they have investigated refrigeration cycles, it may be advantageous to indicate (Table 1) the virtues and weaknesses of the comparable cycles.

Although the power cycle and the refrigerant cycle may be looked at as comparable, they are not mirror images, one of the other. One major distinction resides in the temperature ratios which are of technical interest in commercial applications. For refrigeration the ratios of temperature may be taken from that obtaining in air conditioning (560/510=1.09) to that in the liquefaction of helium (560/8=70). Comparable temperature ratios for power cycles at low-temperature ratio would call for a system with about the same temperatures for heat input and heat rejection, namely 560°R (100°F.) for heat input and 510°R. (50°F.) for heat rejection. Such a low thermal difference steam plant has been proposed but no commercial application has yet operated successfully. At the other extreme, a temperature ratio of 70 would

continued on next page

mean heat input at an average temperature of 40,000°R. Obviously, this is well outside the limit of current technology. The maximum temperature in thermal cycles is obtained in engines involving a nonflow, nonsteady-state process—a temperature of about 4,000°R, corresponding to a temperature ratio of seven. Flow, steady-state processes, such as the gas turbine, are carried out at temperatures to about 2,000°—a temperature ratio of 3.5. The comparable low temperature for a refrigeration process at temperature ratio of 3.5 is 560/3.5= 160°R. (About the liquefaction temperature of oxygen and nitrogen).

The liquefaction of such low boiling gases as hydrogen and helium therefore calls for a range of temperatures between heat absorption and heat rejection, which is outside the range associated with conventional heat-power cycles, and thus dictates some form of series of refrigeration cycles having no true counterpart in power-producing cycles.

Relation of performance criteria to temperature ratio

If T_1 is the absolute temperature of heat input and T_2 that of heat rejection, the efficiency of a reversible power cycle is $E=1-(T_2/T_1)$ whereas for the refrigeration cycle, the conventional figure of merit is the coefficient of performance (C.O.P.).

$$C.O.P.=\frac{1}{(T_2/T_1)-1}$$

In either case, the values of these measures of performance for actual plants should be as high as possible

Table 1.

Power Cycle	Refrigerant Cycle
I. Rankine cycle	I. Vapor-compression cycle (Rankine)
a. Simple Rankine cycle	a. Simple cycle
b. Rankine cycle with superheat	b. Cycle with subcooling of condensate
c. Regenerative feedwater heating	c. Cycle with multistage compression with multistage flashing
II. Binary cycle such as mercury vapor-steam	II. Binary cycles (Two vapor-compression cycles in cascade or compound)
III. (No power cycle comparable to multifluid cascade)	III. Cascade of vapor-compression cycles using different refrigerants
IV. Brayton cycle (Gas turbine cycle)	IV. Claude cycle ("dense air" cycle)
a. With regenerator	a. With heat exchanger for cooling down feed to expansion engine
b. Without regenerator	b. Use of supplementary refrigeration for cooling down feed to expansion engine
V. Supercritical plants using organic liquids as working fluid (Not strictly comparable to refrigerant cycle, but similar in some respects).	V. Hampson or Linde cycle (Cycles using Joule-Thomson expansion of gas)

—necessarily being less than unity for the efficiency of a power cycle, but in the case of coefficient of performance, exceeding five for many air-conditioning and water-chilling applications, and going down to 0.01 or less for helium liquefaction.

For values of T_2/T_1 close to unity, the Rankine (or vapor-compression) cycle is generally indicated; in fact, for power production it is the only cycle that can produce net power. For refrigeration under such conditions there is no justification for cycles II and III. Cycle IV, the "dense air" cycle, has been used for air conditioning and moderate refrigeration temperature differences, because of certain special process requirements which loomed more important than the inordinately high power requirement of this cycle compared with the vapor compression. The high power requirement does not show up in a theoretically ideal cycle but in the actual cycle. The reason is that the net power is represented by the difference between two comparatively large numbers, or expressed in another way, there is a large quantity of negative work involved. Nevertheless, the cycle can work for refrigeration, whereas because of the large work input exceeding the turbine work output, the comparable Brayton cycle is incapable of operating as a power producer until a certain minimum temperature spread is achieved.

With a large temperature spread (a low value of T_2/T_1 for power cycle—a high value of T_2/T_1 for refrigeration cycle), cycle IV comes into its own. It is characterized by simplicity of design and equipment, compared with power cycles Ib, Ic, II, or refrigerant cycles II, III.

At some intermediate temperature range, cycle V is often indicated. How-

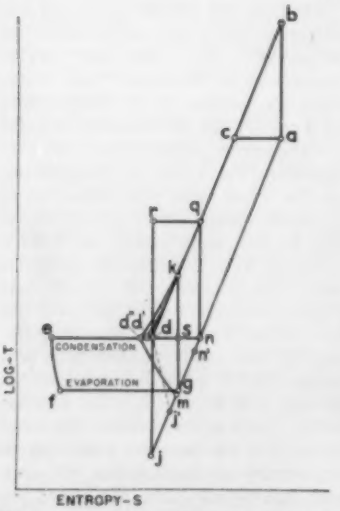

Figure 1. Log temperature vs. entropy —composite of several cycles

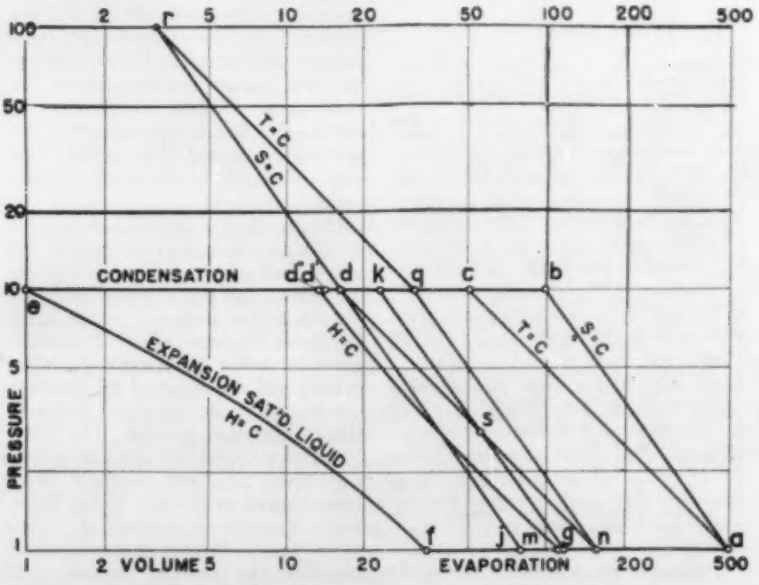

Figure 2. Log pressure vs. log volume—composite of several cycles

ever, the choice of cycle V is limited by the necessity of finding a fluid having critical temperature and pressure conditions in the range close to that required for the expansion.

Graphical presentation

The several cycles are shown graphically in Figures 1-4, one set having coordinates of logarithm of temperature vs. entropy, and the other set logarithm of pressure vs. logarithm of volume. The *P-V* diagrams are included primarily to help indicate the nature of the ideal and nonideal processes being considered. In general, the quantity of mechanical work available from expansion engines may be neglected in a preliminary study and the emphasis placed on the heat quantities involved for which the T-S diagram (or H-S diagram) is sufficient in itself.

After a short discussion of these cycles, some methods will be given of evaluating the performance of actual cycles compared with equivalent reversible cycles. In the liquefaction of hydrogen and for comparable low-temperature refrigeration it is necessary to use a series (or cascade) of refrigeration cycles. This may include different types, as indicated by Chelton, *et al.* (*4*). The composite diagrams of Figures 1 and 2 serve to indicate the features and limitations of each type of cycle.

Composite cycle diagrams—an explanation. Each cycle represents a set of temperature, entropy, pressure, and volume conditions different from the other cycles. The cycles have been laid over each other so that the low temperature and the high temperature of the expansion step more or less coincide regardless of actual process conditions. In practice this could be achieved by judicious selection of working fluid and pressure and temperature conditions. Since the temperature, pressure, and volume are all plotted on a logarithmic scale, the ratios of these values are presented in a form which is significant. The composite *T-S* diagram also serves to show that the expansion through some form of engine (or turbine) offers the opportunity for the largest temperature ratio for refrigeration. For practical reasons, this expansion may be done in more than one stage.

The Carnot cycle, the traditional basis of comparison, will be indicated first. It is shown by the rectangle *nqrd* on the *T-S* plot of Figure 1, which calls for a 100 to 1 pressure ratio as indicated on *P-V* diagram of Figure 2. For low-temperature refrigeration, a pressure ratio of 100 to 1 is in itself within the limits of practical realization. However, even with this comparatively large pressure ratio, the temperature range covered by the ideal cycle is less than the Brayton cycle, *abdj*, which is a reversible cycle and therefore possesses the same efficiency as the Carnot cycle. A further objection to an approximation of the Carnot cycle is the inefficiency of compression from the low pressure and temperature, *n*, to the top temperature, *q*, and the intermediate pressure (shown as 10). Even if temperature *q* is ambient so that no refrigeration is required for rejection of heat along line *qr*, the refrigeration equivalent, not otherwise made available because of compression along path *nq*, is a wasteful process. In the ideal case *rd* and *qn* represent equivalent reversible processes, but in actual cycles, there is an increase in entropy going from *r* to *d* and from *n* to *q*, so that power will be expended solely for the purpose of operating a cycle without the heat exchanger called for in the modified Brayton Cycle (or Ericsson cycle) represented by *acdn*.

The process of compression from *n* to *q*, is hardly, if ever, justified when *n* is appreciably below ambient. The reason is that the inefficiency of compression produces an entropy gain with its equivalent demand for refrigeration which is always less efficient than if the fluid were heated to ambient temperature before being compressed. Some exceptions to this general rule may be justified because of other overriding factors. For example, in the liquefaction of hydrogen by meaens of the Hampson cycle (Joule-Thomson expansion) precooling is done by heat exchange with boiling nitrogen. The performance is affected favorably by evaporation at reduced pressure, say, 0.1 atm. A heat exchanger to bring this low-density nitrogen up to room temperature would be inordinately large. Hence, from the standpoint of capital investment one might choose to operate a compressor with inlet at the saturation temperature of this boiling nitrogen, the compressor bringing the gas up to atmospheric pressure, or higher before passing it into a heat exchanger. Or, if the discharge of the nitrogen compressor is reasonably

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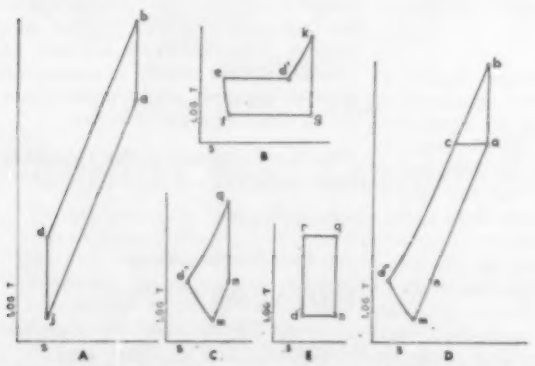

Figure 3. Log temperature vs. entropy—individual cycles
A. Brayton or Claude
B. Rankine (vapor compression with condensation throttling of liquid and evaporation)
C. Hampson or Linde (Joule-Thomson expansion)—compression at low temperature
D. Hampson or Linde (Joule-Thomson expansion)—compression at high temperature
E. Carnot cycle

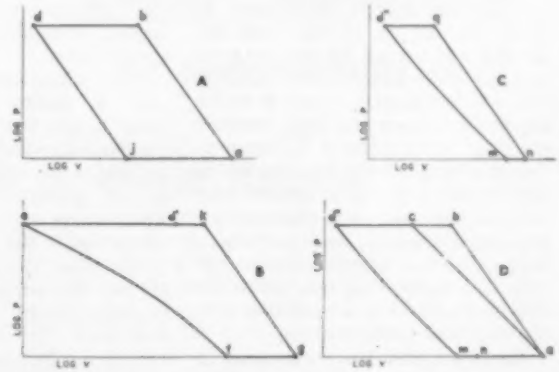

Figure 4. Log pressure vs. log volume—individual cycles
A. Brayton or Claude
B. Rankine (vapor compression with condensation throttling of liquid and evaporation)
C. Hampson or Linde (Joule-Thomson expansion)—compression at low temperature
D. Hampson or Linde (Joule-Thomson expansion)—compression at high temperature

close to ambient, say, —50°F., the gas might be carried directly to the following stage of compression.

Claude cycle or Brayton Ericsson cycle. The names of Brayton and Ericsson applied to these cycles represent an extension of processes involving engines, but traditionally the designations used here have become accepted for steady flow cycles, as in gas turbines. Esthetically, one would like to present a cycle in symmetrical form, for example, *abdj* or *acdn*, so that one has isentropic expansion associated with isentropic compression and isothermal expansion associated with isothermal compression. In practice, there is no justification for such fastidiousness. As just indicated, compression should preferably be effected at ambient temperature, and if that is done, the closer one approaches to isothermal, the less power will be required for the cycle. Where economy is of importance, there is indicated the use of multistage compression with intercoolers between stages in order to approach isothermal performance. The choice of expander arrangement — approaching isentropic process, *dj*, or isothermal process *dn* —depends on both the process requirements and the enthalpy drop for the pressure ratio, temperature, and gas properties. Approach to isothermal conditions, can be made in practical systems only by having two or more expanders with reheat between stages. This type of operation is indicated where refrigeration is required for liquefaction of a gas. For cooling down of the gas, the isentropic path *dj* is preferable as offering the better possibility for good efficiency of the cycle.

A previous paper considered in detail the design of the heat exchanger represented by the low-pressure gas being heated from temperature *n* to temperature *a*, and in so doing cooling down the high pressure gas from temperature *c* to temperature *d*. The idealized diagram shown here indicates the same specific heat for the low- and high-pressure gas streams. In practice, there is likely to be a difference, and the design procedure for handling this difference will be discussed in conncection with the vapor-compression cycle.

Rankine cycle. The counterpart of the simple steam-power cycle, will be referred to as the vapor-compression cycle, most commonly used in refrigeration and generally with condensation taking place with heat being rejected directly to the ambient air or cooling water. The cycle is shown as *gkd' efg*, although it may be modified to approach closer to the Carnot form by stopping isentropic compression at *s* and proceeding with isothermal compression from *s* to *d'*. Actually the nature of the diagram in this region depends largely on the properties of the refrigerant, some having the fluid go into the wet region on compression, rather than into the superheated region, as shown.

For low-temperature plants, this cycle is modified in order to avoid the extra loss which would be incurred by starting compression at point *g*, corresponding to the temperature of the boiling liquid. The modified cycle can be represented by *gnacd' efg*. Points *d'* and *g* are on the saturated-gas line and point *e* on the saturated-liquid line. The saturated liquid at *e* can be subcooled by heat exchange with the low-pressure gas which would be heated to some temperature intermediate between *g* and *n*. However, it would not be practical to approach too closely to *n* because the temperature spread of the low-pressure gas must exceed that of the high-pressure stream owing to the higher specific heat of the high-pressure stream, as indicated by the fact that *d'* is to the left of *d*. A similar limitation often applies to the Claude cycle using an expander. The low-pressure gas entering the heat exchanger must then be at a temperature less than *n*, thus an additional restriction is placed on the approach to isothermal expansion. An alternative method of taking care of the difference in heat capacity of the two streams is considered in a previous paper, namely the use of another refrigerant cycle for providing suitable end-temperature differences in the heat exchangers. Such auxiliary refrigeration would appear justifiable only in rather special cases.

The vapor-compression cycle is used in almost every liquefaction plant as the final step in liquefying the desired product, with the product serving as the refrigerant. The analysis of performance is the same whether one considers the fluid as the refrigerant or the product.

The other application of this cycle at the low-temperature end of a process is in the distillation of liquefied gases. In this application the heat of condensation is used to supply the heat for boiling in the still and the evaporation removes the heat in order to create the reflux required for distillation. Generally this form of refrigeration is most suitable and auxiliary refrigeration is not justified. Nevertheless, there may be instances where refrigeration from expansion engines may improve performance in this type of operation.

Hampson or Linde cycle. Although there is no fundamental distinction in the throttling as between *e and f*, and *d"m*, the name of Hampson or Linde is applied only to the cycle in which there is no phase change from gas to liquid prior to throttling. While ideally, the Joule-Thomson expansion is less efficient than expansion through an engine or turbine, in practice there may be considerable justification for its use. For small plants and for experimental installations, one may prefer to avoid the complexities associated with an expander. These complexities may mean simply the difficulty of obtaining an expander in the time schedule deemed reasonable for pilot plant setup, or the constant shifting around of operating conditions which cannot be handled by an expander designed for a particular gas flow, temperature, and pressure.

The other reason for avoiding the use of an expander is that operation may be far into the wet region where until the present time no completely acceptable design of expander has been developed. Present designs can operate with discharge into the mixed-phase region, but only where the final fluid is either largely vapor or largely liquid.

The low-temperature Hampson, Joule-Thomson expansion cycle is indicated as *mnacd"*, without any specification on just where along path *mn* refrigeration is available. In order to have a significant amount of refrigeration or even to have the system work, it is necessary to provide supplementary refrigeration somewhere along line *cd"*. The exact temperature range at which to remove heat from the high-pressure stream depends on a number of factors which will now be considered next month in connection with an appraisal of the performance of the different types of cycles.

Part II will appear in the December issue of CEP.

NOTATION

See Part II, December.

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Presented at A.I.Ch.E. meeting, Baltimore, Maryland

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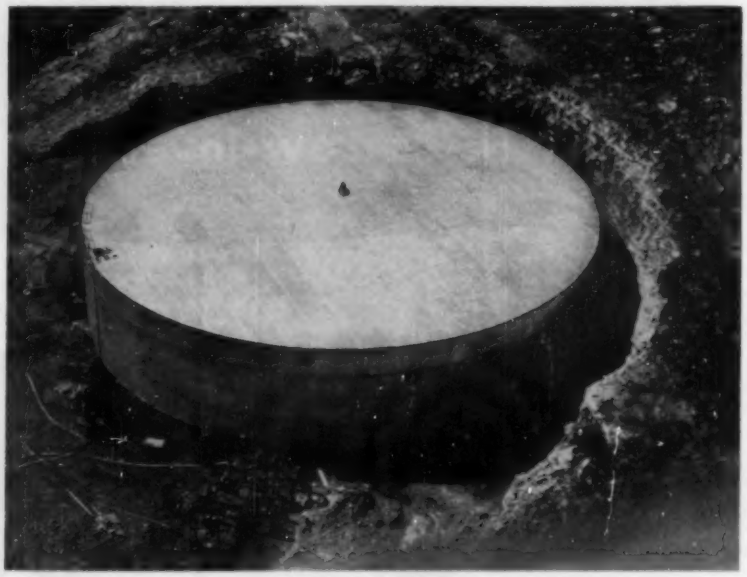
Aluminum use seen increasing in CPI

Weldable aluminum-magnesium alloys may have bright future for chemical process equipment fabrication, structural applications.

"By 1961", said recently a spokesman for Aluminum Co. of America, ". . . . . the chemical, petrochemical, petroleum, food, drug, rubber, and synthetic textile industries promise to triple their aluminum usage, which now stands at about 4% of production." Over the next 4 years, according to Alcoa, the planned expenditure for expansion in these fields amounts to 49% of the total scheduled for all manufacturing industries.

The greatest growth in aluminum use is anticipated in the manufacture of plastics and synthetic fibers, and in industries requiring low-temperature processing.

Alcoa's optimism stems from the metallurgical and corrosion-resisting properties of the recently-developed 5000 series of aluminum-magnesium alloys. Certain of these alloys improve in tensile and yield strength as temperatures are lowered, without signs of embrittlement. It follows that cryogenic applications would seem to be made to order for these relatively untried materials. Alcoa's estimates indicate that tonnage oxygen plants, liquid methane transportation units, and equipment to separate hydrogen isotopes will use some 60 million pounds of aluminum over the next 4 years. Missile fuel tankage alone is expected to consume 75 million pounds over the same period.



All-aluminum storage tank at Mississippi River Chemical Co., Salma, Mo. The tank is 128 ft. in diameter by 26 ft. high, stores 2⅓ million gallons of 83% ammonium nitrate at a temperature of 180°F.

Major new asbestos source in production

Black Lake, Quebec, plant of American Smelting and Refining Co. will produce 100,000 tons/year of asbestos fiber, new industrial applications will be sought

An investment of $36 million, over a four-year period, has now brought into full-scale commercial production an important body of asbestos ore formerly covered completely by two-mile-long Black Lake, some 75 miles south of Quebec, Canada. Discovery and exploration of the ore deposit was due to United Asbestos Corp. Ltd., of Canada, which invested some $2 million in these operations, but which lacked the capital to bring the property into full-scale operation. At this point, with the formation of Lake Asbestos of Quebec, Ltd. as a wholly-owned subsidiary, Asarco came to the rescue with financial and engineering aid.

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New $9 million mill building of Lake Asbestos of Quebec, Ltd., Black Lake, Quebec.

Economies claimed for new steel process

Electric furnace method, developed by Strategic Materials Corp. and Koppers Co., said to cut power factor in half, permit direct smelting of complex ores up to now considered useless.

Preheating and prereduction of the electric furnace charge is claimed as the key to significant process economies possible with the Strategic-Udy method for the production of semi-steel by direct reduction of iron ore.

Principal advantage of the process is said to be the low capital investment required: the cost of a 600 ton/day plant is estimated at approximately $50 per ton of annual capacity. Manufacturing costs for such a plant would vary from $30 to $50 per ton of pig iron, says Koppers, depending on price of power and raw materials. Other advantages are said to be:

Most ores may be used, including flue dust, without special preparation such as agglomerating, sintering, briquetting, or nodulizing;

Complex ores, now of little value, may be used. The process may be designed to remove selectively phosphorous, sulfur, copper, nickel, manganese;

The process permits wide latitude in selection of reductant and fuel; coal, peat, lignite, or coke may be used;

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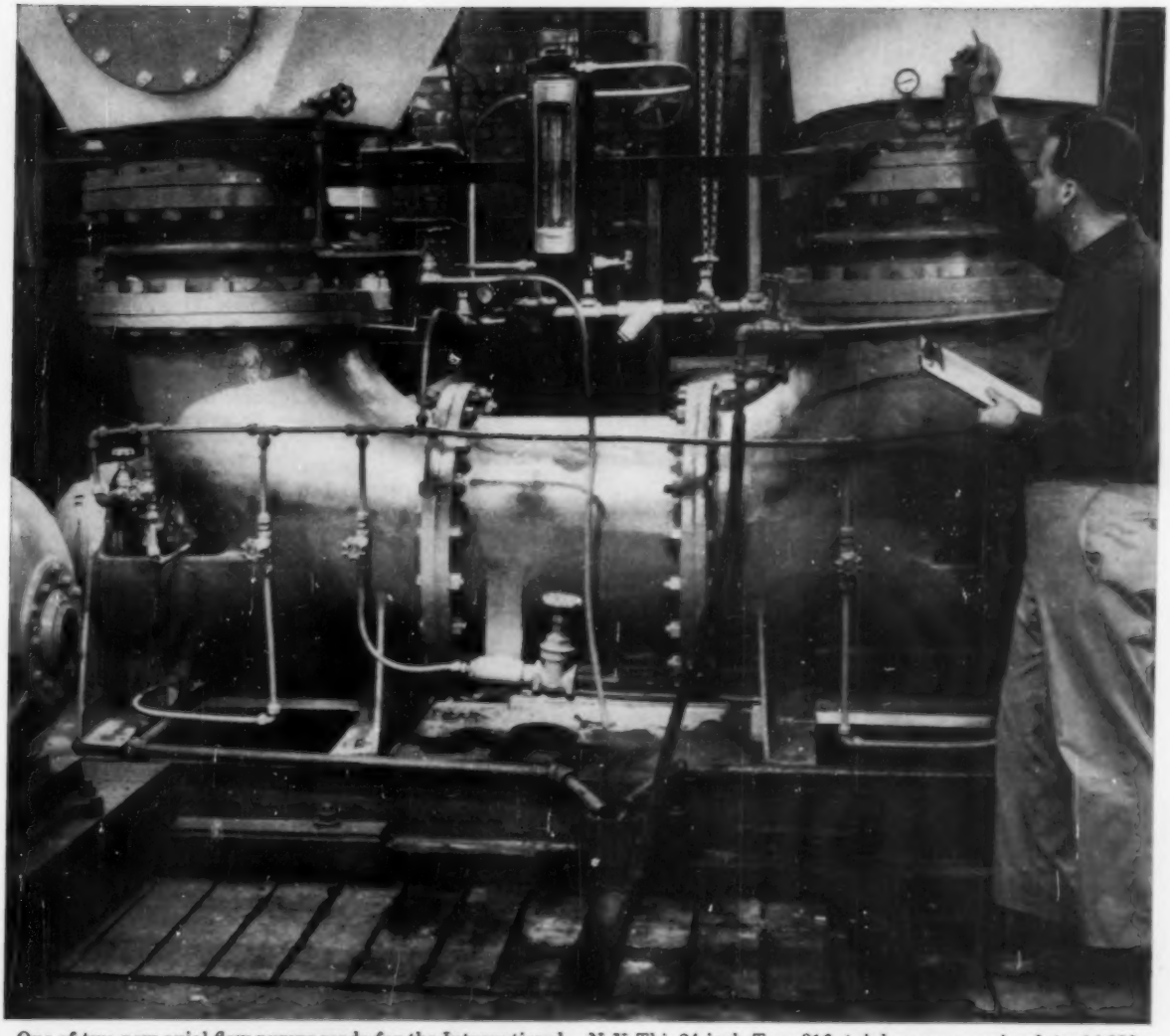

One of two new axial flow pumps made for the International Salt Company by Morris Machine Works of Baldwinsville, N. Y. This 24-inch, Type 316 stainless pump recirculates 14,000 gallons of salt slurry per minute through an evaporator.

Type 316 stainless pump thrives on salt diet —gulps abrasive slurry for 18 years, non-stop

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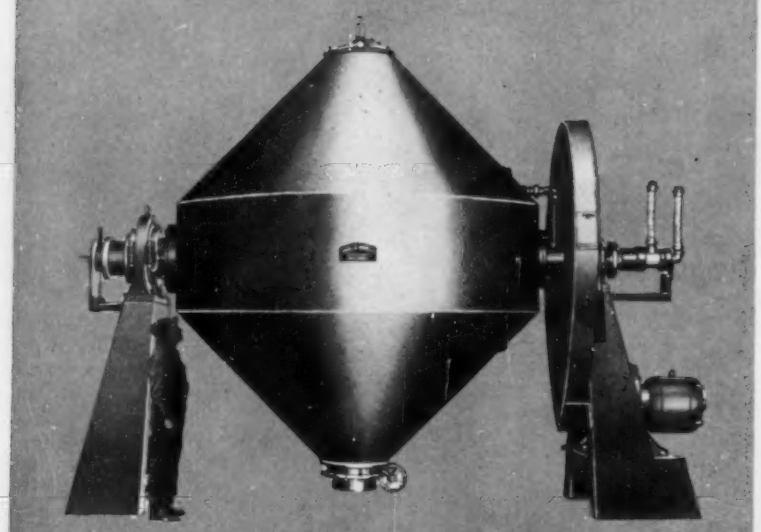

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Asbestos

from page 82

During the draining of Black Lake, 55 billion gallons of water were pumped, and 27 million cubic yards of overburden were removed by dredging from the lake bottom. Now in operation are two main ore bodies on the lake bottom, a third awaits development. Reserves are estimated at 42 million tons. Open-pit mining is expected to be possible for twenty years, after which underground mining may be necessary.

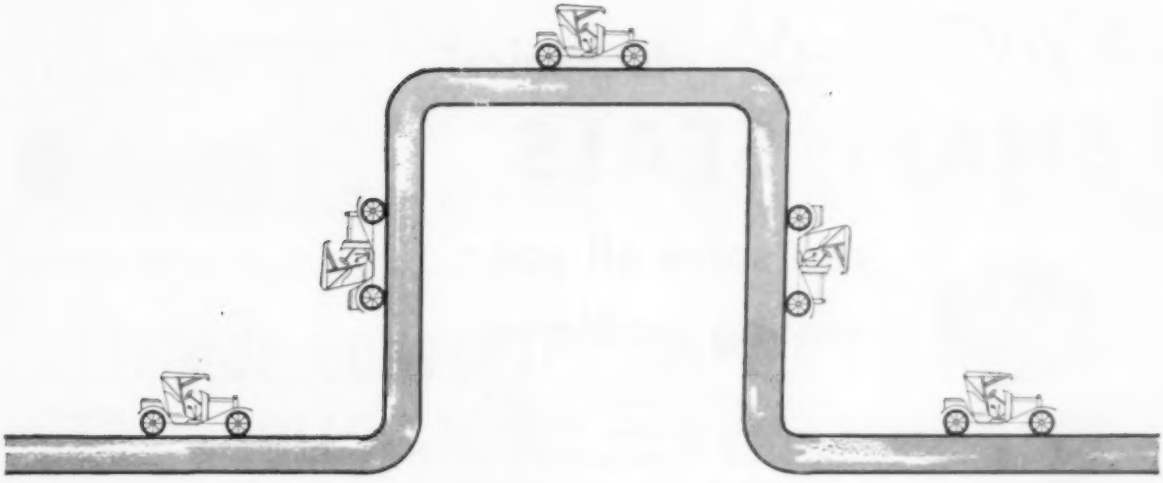
The adjacent mill, erected at a cost of about $9 million is one of the world's biggest vacuum cleaners; 980,000 cu. ft. per minute of air are used to separate the asbestos from the crushed ore. All standard grades of asbestos fiber are being produced, and Asarco has set up a special research project in its South Plainfield, N. J., labs to study new industrial uses for asbestos, and to solve present application problems. Asarco will manufacture no end products; all of the Black Lake production will be available on the open market.

A record shipment of Cobalt-60 (29,100 curies) from Atomic Energy of Canada's Chalk River reactor inaugurated the recent opening of the Beacon, N.Y., industrial radiation laboratory of the Texas Co. Research emphasis at the new facilities will be on the effect of radiation on petroleum and its derivatives to "create new and improved fuels, lubricants, and petrochemicals."

Sale to Japan of a 20 Mev linear accelerator has been announced by High Voltage Engineering. The instrument will be used for research on the properties of radioactive isotopes, analysis of radioactive materials, food and drug sterilization.

Heat exchangers are being rated in minutes instead of days at Alco Products, Inc., Houston, Texas. Installation of a Royal McBee LGP-30 computer is claimed to give an optimum solution to any heat exchanger problem almost instantaneously. Variables fed into the computer are: amount of fluid, heat load, temperatures, viscosity, API gravity, diameter and length of tube, pressure drops and design pressure.

Just dedicated in Skokie, Illinois, is a new $5 million Research and Administration Center for International Minerals & Chemical Corp.



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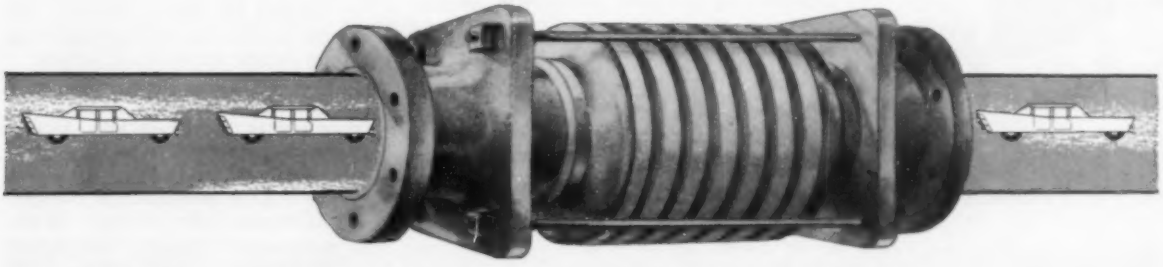


ADSCO Corruflex Expansion Joints guarantee less heat loss and pressure drop . . . require less valuable space . . . and the cost is 30% to 50% lower . . . as compared to expansion bends or loops.

ADSCO Corruflex Expansion Joints are manufactured either as a standard series or as custom units designed for special applications. Corruflex units absorb axial and lateral movement or angular rotational and all combinations of these motions.

ADSCO Corruflex Expansion Joints are manufactured in most commercial alloys, and are designed for service in all phases of petroleum refining, chemical, power, mechanical, heating, and atomic energy installations.

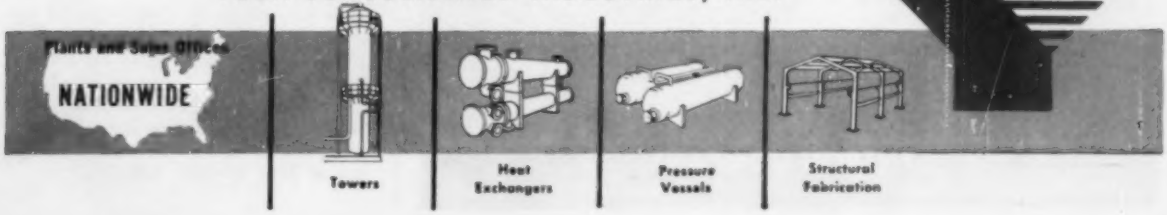
When space and economy are factors in piping consult ADSCO.

CORRUFLEX EXPANSION JOINTS DESIGNED AND MANUFACTURED BY

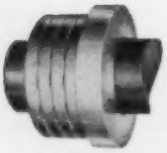
ADSCO DIVISION
20 MILBURN STREET
BUFFALO 12, NEW YORK

YUBA CONSOLIDATED INDUSTRIES, INC.

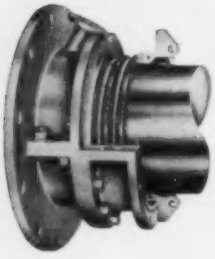
YUBA



SYNTRON Mechanical SHAFT SEALS



can solve all your sealing problems



Install SYNTRON Shaft Seals and forget them. No shutdowns for periodic adjustments or maintenance. They are completely self contained — ready to install. All Sealing faces are precision lapped to provide a positive leakproof seal — will not score or gall shaft.

Whether your problem involves high speed shafts or temperatures, corrosive liquids, synthetic fluids, toxic gases, oil, sea water or just ordinary water . . . There's a SYNTRON Shaft Seal to solve it.

SYNTRON builds positive sealing Mechanical Shaft Seals for every rotating shaft requirement, regardless of shaft size, in a range from ¼" to 48".

Write for information on SYNTRON'S Anti-Friction, Face-Type, oil and roll neck seals.

ME3580

Products of Proven Dependable Quality

Other SYNTRON Equipment

designed to increase production, cut production costs

Vibrators (bins, hoppers, chutes)	Rectifiers (Silicon and Selenium)
Vibratory Feeders	a-c to d-c Selenium Rectifier Units
Vibratory Screens	Electric Heating Panels
Shaker Conveyors	Electric Heating Elements
Vibratory Elevator Feeders	Sinuated Wires
Weigh Feeders	Shaft Seals
Packers and Jolters	Electric Hammers
Hopper Feeders	Concrete Vibrators
Lapping Machines	Paper Joggers

Our representatives will be glad to work with you in selecting the proper equipment for your operation.

Write for FREE catalog information

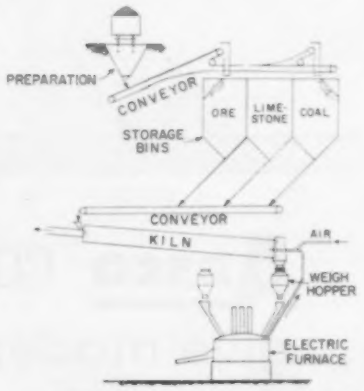
SYNTRON COMPANY
116 Lexington Avenue Homer City, Penna.

Udy-process

from page 82

Close control of carbon content is possible. Pig iron with a carbon content of 3.5%, or semi-steel of 0.5% carbon content can be produced directly.

In the Strategic-Udy process, the



STRATEGIC-UDY PROCESS

electric furnace is preceded by a rotary kiln (see flow diagram). A substantial portion of the heat required for prereducing and preheating the iron ore in the kiln is supplied by burning the carbon monoxide gas produced from the reduction reactions in the electric arc smelting furnace.

A mixture of iron ore, flux, and carbonaceous reductant is fed continuously to the rotary kiln. During the kiln operation, the ore is heated, calcined, and prereduced: the flux (limestone or dolomite) is calcined and combined chemically with the ore. The maximum discharge temperature from the kiln is held between 1,800 and 2,300°F. Sufficient coal is added to accomplish the required two-step reduction.

Hot prereduced ore from the kiln is charged directly to the smelting zone of the electric smelting furnace through insulated feed control bins and controlled feeders. The process employs an open bath technique, with the electrodes from ½ inch above the molten slag to 3 inches submerged in the slag. The charge material enters the periphery of the furnace and forms its own angle of repose. Thus, the space above the electrodes is open, and offers no restriction to the flow of carbon monoxide gas produced by the reduction reactions. The use of such a charging technique is said to permit the charging of fines without difficulty.

LUMMUS

ENGINEERS AND CONSTRUCTORS FOR INDUSTRY

385 Madison Avenue New York 17, N. Y.

LUMMUS COMPLETES IN-PILE TEST LOOP FOR KNOLLS ATOMIC POWER LABORATORY

Engineering Development Center Handling Procurement, Construction and Off-site Operation of Test Loop

The Lummus Company Engineering Development Center, under a subcontract from Knolls Atomic Laboratory, has completed the procurement, construction, and off-site operation of a test loop to be used for irradiation testing by the Knolls Atomic Power Laboratory.

Lummus simulated the confinements of the area assigned to the facility. All out-of-pile equipment was erected, although the in-pile test section was simulated.

The facility consists essentially of a pressurized water heat exchange system and demineralizing equipment. Reactor fuel samples are inserted in the in-pile test section for study under controlled conditions of temperature, pressure and radiation.

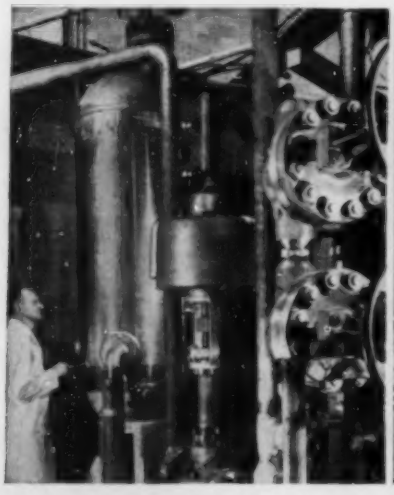
Extreme care has been exercised during fabrication and erection because of the severe operating conditions encountered and the cleanliness required in all equipment subject to radioactivity.

The off-site testing consists of checking the functions of all process and control equipment, instrumentation systems, safety interlocks and alarms.

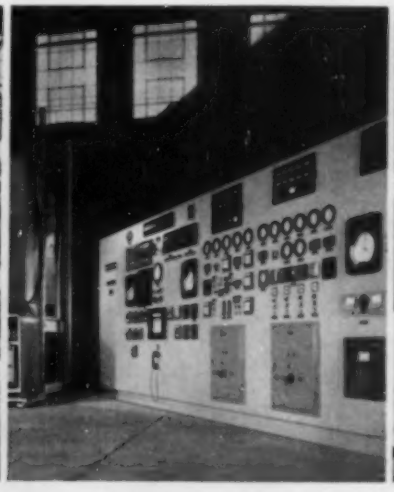
After completion of the test operation in early July, 1958, the equipment was dismantled and shipped to Idaho Falls. The dismantling was handled in a manner which facilitated re-assembly at the operating site, and Lummus provided the services of an engineer to coordinate this phase of the program.

The facilities of The Lummus Company Engineering Development Center in Newark, N. J. are uniquely suited to unusual projects of this nature. The necessary floor space, headroom, materials handling equipment, transportation facilities, and utilities are all available at the Center. Lummus' technical, maintenance, and operating personnel are all skilled in design, fabrication and operation of pilot plants and small scale process equipment. For more information write for our illustrated brochure No. 105, on the "Engineering Development Center."

THE LUMMUS COMPANY, 385 Madison Avenue, New York 17, N. Y., Houston, Chicago, Washington, D. C., Montreal, London, Paris, The Hague, Caracas, Maracaibo. *Engineering Development Center,* Newark, N. J.



Pressurizer, main flow control valve, loop block valves.



Test Loop Control Panel.

Loop pump volutes prepared with special cover plates for hydrostatic testing.

DESIGNED TO HANDLE THE FUELS OF THE FUTURE as well as those of today, Peerless Hydro-Line® transfer type and process type, encased close coupled vertical pumps are providing the necessary "big boost" to pumping operations throughout industry. Excellent operating records in refinery, line booster, condensate and chemical processing service have proved the efficiency and practicality of Peerless Hydro-Line pumps. Their space-saving vertical design makes the most of available plant room; their outstanding NPSH (net positive suction head) characteristics make them easily adaptable to future system requirements; their sound design and sturdy construction endow them with a long, trouble-free life. For utmost reliability and peak performance, select your pumps from the complete line of Peerless Hydro-Line Pumps.

WRITE FOR ILLUSTRATED BULLETIN NO. B-1700.

PEERLESS PUMPS

Putting Ideas to Work

fmc
FOOD MACHINERY AND CHEMICAL CORPORATION

FOOD MACHINERY AND CHEMICAL CORPORATION
Peerless Pump Division
Plants: LOS ANGELES 31, CALIFORNIA and INDIANAPOLIS 8, INDIANA
Offices: New York, Cleveland, Chicago, St. Louis, San Francisco, Atlanta, Plainview, Lubbock, Phoenix, Albuquerque, Los Angeles, Fresno. Distributors in Principal Cities. Consult your telephone directory.

CEP Data Service

FREE — Detailed technical data on products and services advertised this month. PLUS —Carefully-selected new offerings of free technical literature. IT'S EASY — Merely circle appropriate numbers on the Data Post Card and mail—no postage required.

Numbers followed by letters refer to equipment, materials, and services advertised in this issue. Numbers indicate pages, and letters position on the page: L, left; R, right; T, top; B, bottom. A indicates full page; IFC, IBC, and OBC are cover advertisements.

UNFOLD CARD AND CIRCLE NUMBERS ➡ ➡ ➡ ➡ ➡ ➡ ➡ ➡

SUBJECT GUIDE to advertised products and services

EQUIPMENT

Agitator, portable. High and medium speed. 1/6 to ¾ hp. Bulletin 581 from New England Tank & Tower Co. Circle 135R.

Barrel Handler. Free illustrated brochure details advantages of the Vac-U-Lift system. Vac-U-Lift Co. Circle 144L.

Belts, woven-wire. New 130-page reference manual gives mesh specifications, design data, metallurgical data. Cambridge Wire Cloth Co. Circle 104L.

Castings. Kutztown Foundry & Machine Corp. Circle 142BR.

Clarifiers. For use as initial part of ion-exchange water purification systems. Details from Illinois Water Treatment Co. Circle 124L.

Coils, heating. Technical data and prices from Dean Products, Inc. on the Dean Thermo-Panel Coil. Circle 155TR.

Compressors. Horizontal or vertical, single-and multi-stage, 20 to 150 hp, pressures to 5,000 lb./sq. in. Ingersoll-Rand. Circle 16A.

Compressors, large-volume, medium pressure. Technical data from Brown Boveri Corp. Circle 125A.

Condenser, tower-type. Details from Croll-Reynolds Co. on the "Convactor". Circle 34A.

Connectors, pipe, flexible. In Teflon, for pressures to 75 lb./sq. in. Data from Crane Packing Co. Circle 14L.

Controls, sound and pulsation. Com-

continued on page 92

MATERIALS

Carbon, activated. Data from National Carbon Co. on new grade of activated carbon specially-designed as catalyst support. Circle 38A-B.

Catalysts, polymerization. Bulletin 510 from Metal Hydrides, Inc. on polymerization catalysts from sodium hydride. Circle 129A-B.

Cloth, wire. In all standard widths, all meshes, all commercial metals. Data from Newark Wire Cloth Co. Circle 100L.

Desiccants. Data from Linde Co. on properties and applications of Molecular Sieves. Circle 122L.

Diatomaceous Earth. Bulletin E-41 from Dicalite Dept., Great Lakes Carbon Corp., gives complete tables of physical and chemical characteristics. Circle 117A.

Filter Paper. Technical information and free samples of filter paper from Eaton-Dikeman Co. Circle 138R.

Isosebacic Acid, esters of. Data from U.S. Industrial Chemicals Co. on new series of vinyl plasticizers. Circle 23-24A.

Materials of Construction, corrosion-resistant. New, 12-page bulletin and corrosion guide from Electro Chemical Engineering & Mfg. Co. Circle 13A.

Packing, Teflon. Brochure from Flexrock Co. Circle 155BR.

Silicone Finish, heat-resistant. Data from Midland Industrial Finishes Co. on Sicon Finishes. Circle 28L.

Sodium Hydride, in oil dispersions. Brochure on applications from Metal Hydrides, Inc. Circle 129A-A.

SERVICES

Design and Construction, plants. Blaw-Knox, Chemical Plants Division, Circle 95A.

Design and Construction, plants. General Bulletin from Chemical Construction Corp. describes design, engineering, and construction facilities. Circle 25A.

Design and Construction, plants. Brochure from Lummus Co. describes facilities of its New Jersey Engineering Development Center. Circle 87A.

Design and Construction, plants. C. W. Nofsinger Co. Circle 154B.

Design and Construction, alkyd resin plants. Details from Industrial Process Engineers. Circle 132L.

Design and Construction, hydrogen plants. Technical data from Girdler Construction Division, Chemetron Corp. Circle 103A.

Design and Construction, low-temperature separation plants. American Air Liquide. Circle 133A.

Design and Construction, refineries. Wyatt Metal & Boiler Works. Circle IFC.

Design and Construction, urea plants. Brochure from M. W. Kellogg Co. Circle 27A.

continued on page 92

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CEP's DATA SERVICE—Subject guide to advertised products and services

Equipment *continued from page 90*

plete catalog from Pulsation Controls Corp. describes suction mutes, liquid and gas pulse traps, other control devices. Circle 118L.

Controls, temperature. Data from Claud S. Gordon Co. on pyrometers, thermocouple wire. Circle 156L.

Control Systems, visual. Free, 24-page Booklet BE-40 from Graphic Systems. Circle 150BR.

Conveyors, closed-belt. For fragile bulk materials. Data from Stephens-Adamson Mfg. Co. Circle 149R.

Coolers, liquid. Bulletin 257-C from Doyle & Roth Mfg. Co. Circle 106L-C.

Couplings, quick. In stainless, aluminum, malleable iron, brass. Ever-Tite Coupling Co. Circle 18A.

Crushers, jaw. Bulletin 062 from Sturtevant Mill Co. Circle 146L-A.

Crushers, rotary, fine. Bulletin 063 from Sturtevant Mill Co. Circle 146L-B.

Crushing Rolls. Bulletin 065 from Sturtevant Mill Co. Circle 146L-C.

Cryogenic Systems. Technical data and consulting services offered by Air Products, Inc. Circle 105A.

Crystallizers. Open and closed types, continuous and batch types. Data in Bulletin CE-57 from Struthers Wells Corp. Circle 12A.

Deionizers. Seven sizes, flow rates from 5 to 120 gal./hr. Descriptive bulletins from Ion Exchange Products, Inc. Circle 147TL.

Dryers. Free pilot plant testing service on your materials available from Louisville Dryer Division, General American Tansportation Corp. Circle 115A.

Dryers, pan, agitated. Technical Bulletin 351 from Bethlehem Foundry & Machine Co. gives drying coefficients and power requirements. Circle 127A.

Dryers, pilot plant. Details from C. G. Sargent's Sons Corp. Circle 110L.

Dryers, vacuum, rotary. Folder from Paul O. Abbe describes the "Rota-Cone" vacuum dryer. Circle 84L.

Equipment, pilot plant. Reactors, heat exchangers, pressure vessels, columns, tanks. Bulletin from Doyle & Roth Mfg. Co. Circle 106L-D.

Equipment, processing. A and B sections of dictionary of products processed in unit machines made by Sprout, Waldron & Co. Circle 9A.

Equipment, processing. Engineering data from Alsop Engineering Corp. on filtration, mixing, storage, and pumping equipment. Circle 108L.

Equipment, processing. Dryers, coolers, furnaces, reactors, presses, pilot plants. Data from Edw. Renneburg & Sons Co. Circle 139R.

Equipment, processing, corrosion-resistant. Buyers Guide to Corrosion-resistant Process Equipment offered by Pfaudler Co. Circle 7A.

Evaporators. Catalog 372 from Buflovak Equipment Division, Blaw-Knox Co. Circle 99A.

Feeders. Tank, agitator, and pump combined in one operating system. Technical details from Neptune Pump Mfg. Co. Circle 146BR.

Feeders, bulk material. Technical data from B. F. Gump Co. on Draver feeders. Designed to handle ounces to thousands of pounds per hour. Circle 3R.

Filters. Standard filtration areas from 5 to 500 sq. ft. Technical data from Croll Reynolds Engineering Co. on the ClaRite filter. Circle 137R.

Filters. Wide variety of continuous vacuum and pressure designs. Eimco Corp. Circle 36A.

Filters, cylinder-disc. Constant seal of filter media. Bulletin 19-S from Ertel Engineering Corp. Circle 142BL.

Filter Media, metal. Operation from minus 420 to 1,200°F, pressures to 6,000 lb./sq. in. Brochures from Purolator Products, Inc. Circle 113A.

Filter medium, carbon. Data on "Anthrafilt" from Palmer Filter Equipment Co. Circle 120L.

Filter Presses. With automatic pressure control. Details from E. D. Jones & Co. Circle 141L.

Fused Quartz Ware. Technical data from Thermal American Fused Quartz Co. Circle 154L.

Gaskets, Teflon-jacketed. Catalog AD-154 from United States Gasket Co. Circle 10L-A.

Grinding Systems. Packaged plants include structural steel, processing equipment, motors—ready for erection. Details from Allis Chalmers. Circle 107A.

Heads, safety. Wide range of metals and plastics for disc components. Data from Black, Sivalls & Bryson, Inc. Circle 32L.

Heat Exchangers. Bulletin 58E from Graham Mfg. Co. on Heliflow exchangers. Circle 114L.

Heat Exchangers. Bulletin 158-HE from Doyle & Roth Mfg. Co. Circle 106L-A.

Heat Exchangers, self-cleaning. With movable baffles, operated manually or automatically. Bulletin 1000 from Davis Engineering Corp. Circle 145R.

Heaters, electric. Low-frequency induction heating system for welding, preheating, stress relieving. Brochure from Electric Arc, Inc. Circle 147R.

Heaters, steam-jet. Complete details on all types from Schutte and Koerting Co. Bulletin. Circle 8A.

Indicator, bin-level. Technical data from Bin-Dicator Co. Circle 147BL.

Ion Exchange Equipment. Bulletin 200 from Industrial Filter & Pump Mfg. Co. Circle 121A.

Irradiation Systems, gamma. Data from Atomic Energy of Canada on Cobalt-60, Gammacell 220 irradiator, design and consulting services. Circle 33A.

Joints, ball, flexible, steam-jacketed. In 2, 3, 4, and 6 in. sizes. New catalog 215B from Barco Mfg. Co. Circle 112L.

Joints, expansion. Available in most commercial alloys. Details from Adsco Division, Yuba Consolidated Industries. Circle 85A.

Joints, expansion, Teflon. Catalog AD-137 from United States Gasket Co. Circle 10L-B.

Laboratory Equipment. Free 180-page catalog of laboratory equipment from Metalab Equipment Co. Circle 124BR.

Materials Handling Equipment. Complete catalog 358 from Stephens-Adamson Mfg. Co. Circle 141R.

Mills, hammer. Bulletin 084 from Sturtevant Mill Co. Circle 146L-D.

Mills, hammer. For coarse grinding and crushing of material up to 10 in. Data from Bauer Bros. Co. Circle 148BL.

Mixers. Complete information from Charles Ross & Son Co. on heavy-duty mixers and kneaders. Circle 149L.

Mixers. Six standard models, 1 to 200 hp. Special units to 500 hp. Catalog A-27 from Philadelphia Gear Corp. Circle 30-31A.

Mixers. Condensed catalog from Mixing Equipment Co. Bulletin 109. Circle OBC-F.

Mixers, batch. Bulletin B-12 from Gruendler Crusher & Pulverizer Co. Circle 150TL.

Mixers, batch. New, 1958 processing equipment catalog from Troy Engine & Machine Co. gives details of angular mixers, colloid mills, roller mills, unit blenders. Circle 140BR.

Mixers, laboratory and small-batch. Bulletin 112 from Mixing Equipment Co. Circle OBC-E.

Mixers, portable. ⅛ to 3 hp. Bulletin 108 from Mixing Equipment Co. Circle OBC-C.

Mixers, side-entering. 1 to 25 hp. Bulletin 104 from Mixing Equipment Co. Circle OBC-D.

Mixers, top-entering. Propeller types, ¼ to 3 hp. Bulletin 103 from Mixing Equipment Co. Circle OBC-B.

Mixers, top or bottom-entering. Turbine, paddle, and propeller types, 1 to 500 hp. Bulletin 102 from Mixing Equipment Co. Circle OBC-A.

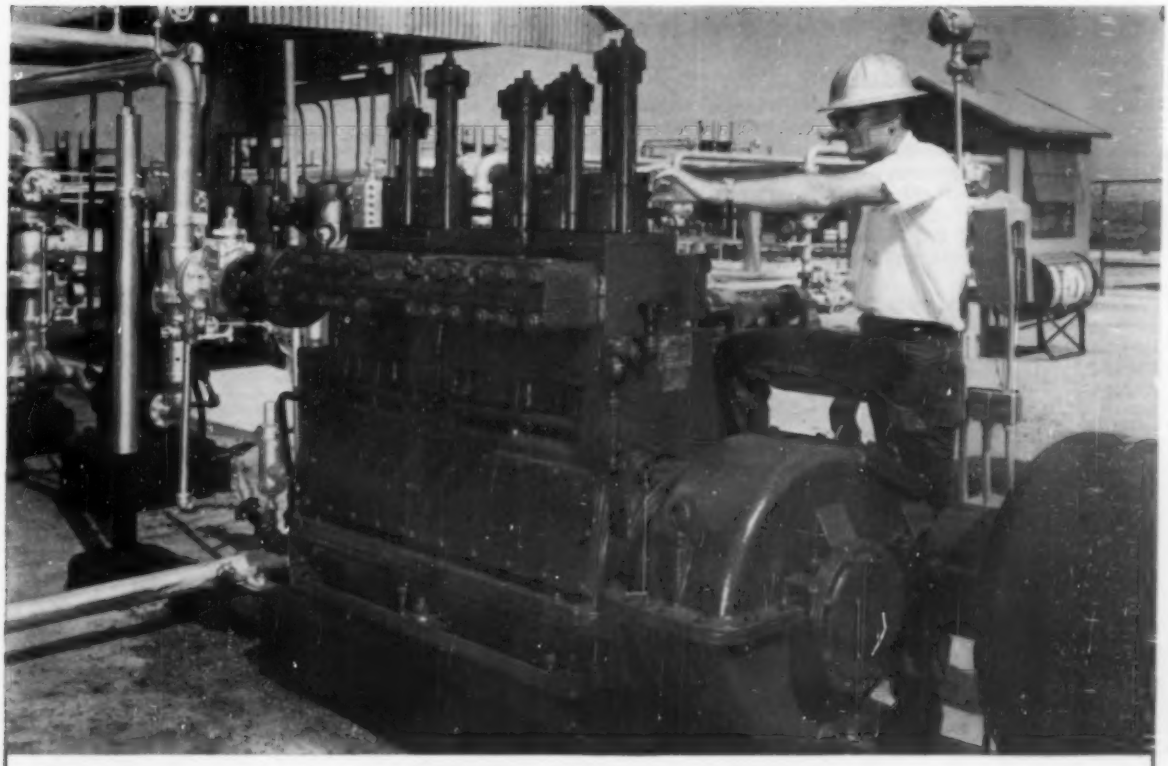
continued on page 94

Services *from page 90*

Fabrication, process equipment. Bulletin 550 from Koven Fabricators, Inc. Circle 136L.

Modernization Ideas. Booklet from Allis-Chalmers titled "59 Ideas for Modernization in 1959". Circle 108R.

Process Simulation. Data from Electronic Associates, Inc. on use of computers for process simulation. Circle 22A.



FIELD REPORT

SERVICE: LP-Gas Injection
Burnell—North Pettus Cycling Plant

PUMP: 1½" x 5" Aldrich Quintuplex

OPERATION STARTED: June, 1950

EXPERIENCE TO DATE:

Continuous service...pump delivers 52 gpm at 3000 psi. Routine maintenance annually...plungers are repacked as necessary. Customer reports: "complete satisfaction" with the performance of the Aldrich pump.

Field parts stock available in Carmi, Ill.; Calgary; Casper, Wyoming; Charleston, W. Va.; Houston; Los Angeles; Odessa and Tulsa. For further information, write the Aldrich Pump Company, 20 Gordon Street, Allentown, Pa.

the toughest pumping problems go to ALDRICH

CEP's DATA SERVICE—Subject guide to advertised products and services

Equipment *from page 92*

Nozzles, spray. Complete catalog 24 from Spraying Systems Co. Circle 150BL.

Nozzles, spray. Comprehensive spray nozzle catalog from Binks Mfg. Co. Circle 120BR.

Nozzles, spray. Spray Engineering Co. offers performance data on complete line. Circle 102L.

Packing, tower. Booklet from Harshaw Chemical Co. gives details of Tellerette packing. Circle 97A.

Packing, tower, Intalox Saddles. Technical data in bulletin S-29 from U.S. Stoneware Co. Circle 26A.

Piping, alloy, large-diameter. Fabricated steel pipe of 14 O.D. or larger. Data from Posey Iron Works, Inc. Circle 142T.

Piping, high-alloy, centrifugally-cast. O.D. from 2½ to 24 in., lengths up to 15 ft. Data from Duraloy Co. Circle 128L.

Piping, plastic. Brochure from Kraloy Plastic Pipe Co. gives specifications of high-impact plastic pipe and tubing. Circle 138L.

Piping, Teflon-lined. Completely inert to all corrosives. Bulletin TS-1A from Resistoflex Corp. Circle 119A.

Pumps, centrifugal, corrosion-resistant. Catalog and performance curves on the "Flex-Seal" pump from Bart Mfg. Corp. Circle 148TL.

Pumps, centrifugal, PVC. All liquid-exposed parts of unplasticized, unmodified polyvinyl chloride. Booklet from Vanton Pump and Equipment Corp. Circle 29A-A.

Pumps, controlled-volume. Up to ten liquid ends can be connected to one variable speed drive. Data from Milton Roy Co. Circle IBC.

Pumps, corrosion-resistant. Heads to 345 ft., capacities from ½ to 3,000 gal./min. In 14 standard alloys. Data from Duriron Co. Circle 123A.

Pumps, graphite, centrifugal. Data from National Carbon Co. on 3 new sizes of "Karbate" impervious graphite pumps. Circle 38A-A.

Pumps, leakproof. For temperatures to 1,000°F, pressures to 5,000 lb./sq. in. Details from Chempump Corp. Circle 101A.

Pumps, peristaltic action. Capacities 0.2 cc./min. to 4.5 gal./min. Catalog from Sigmamotor, Inc. Circle 154R.

Pumps, process. Data from Aldrich Pump Co. on all types. Circle 93A.

Pumps, sealless, plastic. In capacities from ⅓ to 40 gal./min. Booklet from Vanton Pump and Equipment Corp. Circle 29A-C.

Pumps, vertical. Bulletin B-1700 from Peerless Pump Division, Food Machinery and Chemical Corp., describes its "Hydro-Line" vertical pumps. Circle 88A.

Reactor, low-pressure, stirred. For pressures to 1,200 lb./sq. in. at 350°C. Details from Pressure Products Industries, Inc. Circle 140L.

Rectifiers, semi-conductor. Technical data and consulting services from Allis-Chalmers. Circle 109A.

Screens. From 12 inches to 325 mesh. Screen selection guide 25C6177M from Allis-Chalmers. Circle 111A.

Seals, shaft, mechanical. Anti-friction, race-type, oil and roll neck seals. Data from Syntron Co. Circle 86L.

Separators, entrainment. Improve performance of vacuum towers, distillation equipment, absorbers, evaporators. Data from Otto H. York Co. Circle 4A.

Separators, entrainment. Low pressure drop, removable vanes. Data from Peerless Mfg. Co. Circle 17A.

Tank Transports. Bulletin 257-T from Doyle & Roth Mfg. Co. Circle 106L-B.

Tubes, filter, porous carbon. Diameters to 6⅝ in., lengths to 36 in. Sizes and prices from National Carbon Co. Circle 38A-C.

Tubing, small-diameter, alloy. Data Memorandum 20, "Tubing for Atomic Power," from Superior Tube Co. Circle 131A.

Valves. In any metal or alloy, for every flow control problem. Data from Wm. Powell Co. Circle 15A.

Valves, gate, plastic. Now available with socket-weld plugs, in sizes from ½ to 2 in. Booklet from Vanton Pump and Equipment Corp. Circle 29A-B.

Valves, porcelain. Description and specifications from Lapp Insulator Co. Circle 11A.

Viscometers. Complete technical data from Brookfield Engineering Laboratories, Inc. Circle 130L.

Waste Disposal Systems. Data from Dempster Brothers on complete line of waste disposal systems. Circle 81A.

CEP's DATA SERVICE—Subject guide to free technical literature

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD, PAGE 91

EQUIPMENT

301 Actuators, valve. Conversion unit, made by C. H. Wheeler Mfg. Co., converts hand-operated valves to automatic operation. Catalog with technical details, installation instructions.

302 Analyzer, gas. The Thermatron, made by Mine Safety Appliances Co., can measure the concentration of one gas in a multi-component mixture selectively and continuously. Technical data.

303 Compressors, low-pressure. Specifications on 3 models, from 756 to 7392 cu. ft./min. Eight-page bulletin from Joy Mfg. Co.

304 Compressors, "Spiraxial." Bulletin from Roots-Connersville Blower presents design and construction data as aid to proper selection and application. Capacities from 1,000 to 12,000 cu. ft./min., pressures to 15 lb./sq. in.

305 Computers, analog, in-process. *continued on page 96*

MATERIALS

379 Catalyst, hydrogenation. Bulletin from Catalysts and Chemical, Inc. describes its now C36 selective hydrogenation catalyst for purification of olefin streams.

380 Chemicals, industrial. Product list from Foote Mineral Co. gives technical data on more than sixty chemicals, metals, and minerals.

381 Cloth, wire, titanium. From 4 to 120 mesh, diameters from 0.080 to 0.001 in. Technical data from Newark Wire Cloth Co.

382 Coating, nickel-alloy. Bulletin from General American Transportation, Kanigen Division, describes the Kanigen process for deposition of a corrosion-resistant nickel alloy coating on metals without use of electricity.

383 Coatings, protective. Bulletin from Lithcote Corp. gives details of phenolic, epoxy, other protective coatings. *continued on page 98*

SERVICES

395 Chemistry of Cyanidation. Technical publication from American Cyanamide analyzes problems inherent in cyanidation of copper, zinc, nickel, arsenic, and antimony ores, carbonaceous materials, sulfide minerals, flotation reagents.

396 Chromatography, gas. "Bibliography on Gas Chromatography and Some Related Methods," offered by Consolidated Electrodynamics Corp.

397 Computing Center Services. Booklet from Electronic Associates, Inc. describes the facilities and services offered by its computing centers in the U. S. and abroad.

398 Design and Construction, nitric acid plants. Brochure from Girdler Construction Division, Chemetron Corp., gives flow diagram, operating details of the Du Pont high-pressure ammonia oxidation process.

Blaw-Knox builds pace setting nitrogen plant for Columbia-Geneva Steel Division of U.S. Steel Corporation. This is the first U.S. installation in a major steel plant to use coke oven gas as the source of hydrogen for ammonia production. Located near Provo, Utah, the new plant includes administration, maintenance and compression buildings . . . ammonia synthesis, storage and shipping . . . nitric acid production, ammonium nitrate production, prilling, packaging and shipping.

U.S. STEEL MAKES NEW ADVANCE IN CHEMICAL OUTPUT

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Blaw-Knox Company, Chemical Plants Division with headquarters in Pittsburgh. Branch offices in New York, Chicago, Haddon Heights, New Jersey, Birmingham, Washington, D. C., and San Francisco.

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BLAW-KNOX

CEP's DATA SERVICE—Subject guide to free technical literature

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD, PAGE 91

Equipment *from page 94*

Bulletin from Southwestern Industrial Electronics Co. describes technical details, process control applications.

306 Controls, magnetic. Designed for pump control or solenoid or motor-operated valves in tanks, sumps, or vessels. Data from Magnetrol on two new models.

307 Controller, ratio. Specifications, technical data from Pulsation Controls Corp. on the Everett Dynamic Ratio Controller for two-component blending, or for rate controlling where many components are involved.

308 Control Pilot, liquid-level. Bulletin from Leslie Co. gives details of the Level-Matic control pilot. Sectional views, characteristics, applications.

309 Dryers, convection. Dimensions, utilities required, selection chart, design features given in bulletin from C. M. Kemp Mfg. Co.

310 Dryers, drum. Mechanical details of atmospheric and vacuum dryers, single or double drums. Specifications and dimensions. Bulletin from Blaw-Knox, Buflovak Equipment Division.

311 Dryers, steam-tube. Selection and construction data, design data sheet, contained in bulletin from Louisville Dryer Division, General American Transportation Corp.

312 Dryer-Blender, glassed-steel, conical. Can impregnate, concentrate, react, or coat in a single operation. Available in 2, 4, 6, and 8 ft. inside diameters, capacities from 3 to 165 cu. ft. Bulletin from Pfaudler Co.

321 Evaporator. Technical data from Blaw-Knox, Buflovak Equipment Division, describes the Roto-Vak, designed for concentration of viscous, foamy, or heat-sensitive materials.

322 Fans, industrial, "Tubeaxial." Catalog from Westinghouse Sturtevant Division charts recommended stack sizes, maximum horsepower, maximum motor speed for variable stack velocities and air flow.

323 Flowmeters, magnetic. New obstructionless magnetic flowmeter described in technical bulletin from Fischer & Porter Co.

324 Flowmeters, plastic. New bulletin from Builders-Providence describes Dall flow tubes made of fiberglas-reinforced epoxy or polyester resins with metallic throat lining. Dimensions and cost-comparison tables, performance charts.

325 Flowmeters, turbine-type. Bulletin from Pottermeter Co. describes flowmeters for flow rates of from 0.1 to 25,000 gal./min. at pressures to 35,000 lb./sq. in.

326 Grinders. Packaged unit made by Allis-Chalmers consists of vibrating mill and all auxiliary equipment. Designed for capacities up to 1 ton per hour. Technical data.

327 Heaters. New, 4-section catalog from D. J. Murray Mfg. Co. describes GRID cast-iron steam heat transfer surface unit heaters, blast heaters, and radiators. Air distribution charts, heating capacities, conversion tables.

328 Heaters, electric. New, 52-page booklet from General Electric gives engineering data on pipe heaters, immersion heaters, new ratings and configurations of tubular heaters.

329 Instruments, hydrostatic. Bulletin from Uehling Instrument Co. describes instruments for measuring pressure, vacuum, liquid level.

330 Instruments, indicating and controlling. Bulletin from United States Gauge describes complete line of industrial indicating and recording instruments for temperature and pressure.

331 Instruments, process. Fifty-two-page catalog from Fischer & Porter covers indicators, transmitters, recorders, controllers for flow, pressure, temperature, density, viscosity, and consistency.

332 Irradiation Unit. A self-contained cobalt 60 irradiator for research on effects of ionizing radiation on plastics, chemicals, petroleum intermediates. Bulletin on the "Hotrodder" from Nuclear Systems, Division of Budd Co.

333 Jets, steam, corrosion-resistant. For heating, circulation, agitation, digestion. Technical details, steam consumption charts in bulletin from Duriron Co.

334 Manometers. Twenty-four-page catalog from King Engineering Corp. gives details of U-type, well type, and inclined-tube manometer, manometer indicating liquids, accessory equipment.

335 Nozzles, spray, hollow-cone. Data sheet from Austin Mfg. Co. describes the "Hydo" nozzle, molded from butyrate for resistance to corrosion, electrolytic action, and friction.

336 Piping, alloy. Bulletin from Bristol Metal Products Corp. gives details of its line of pipe and pipe fittings in stainless, alloy steels, and aluminum.

337 Piping, cast-iron chrome-nickel alloy. Sizes, dimensions, approximate weights given in bulletin from Attalla Pipe and Foundry Co.

338 Piping, hard-rubber. Dimensions, specifications of hard rubber pipe, fittings, and valves from Luzerne Rubber Co. Table of chemical resistance.

339 Piping, plastic. Physical and mechanical properties, chemical resistance, flow characteristics, working pressures of new type plastic pipe given in bulletin from Southwestern Plastic Pipe Co.

340 Piping, PVC. Sixteen-page manual from Carlon Products Corp. gives selection and application data on complete line of polyvinyl pipe, tubing, and fittings. Many charts and tables.

341 Power Drives, multiple. The Varidyne provides a simple means of controlling the speed of standard A.C. induction motors. Brochure from U. S. Electrical Motors.

342 Processing Units, batch. For both exothermic and endothermic reactions over wide range of operating pressures and temperatures. Bulletin from Artisan Metal Products, Inc.

343 Protectors, condenser-tube. New type protectors in fracture-proof Nylon available from Crane Packing Co. Data.

344 Pulverizers, jet. For dry pulverizing to micron-size powders. Eight sizes, mill diameters from 2 to 36 in. Bulletin from Jet Pulverizer Co.

continued on page 98

DEVELOPMENT OF THE MONTH

SLIDE SELECTOR FOR GAUGES AND VALVES

(Circle 601 on Data Post Card)

Easy selection of the correct size and type of liquid-level gauge or valve for any job is possible with a new slide selector offered by Jerguson Gage & Valve Co. The selector gives sizes numbers, visible glass and center-to-center connections for the complete line of Jerguson gauges in all types and pressure groups. Also individual pressure-temperature graphs on each type of gauge, illustrations of various gauge-valve combinations, and cross-section illustrations and data on various types of valves. For one of these handy selectors, Circle 601 on Data Post Card.

TOWER PACKING

All the facts about HARSHAW *tellerettes*

Contained in this comprehensive booklet discussing the application of Harshaw Tellerettes to tower packing.

Subjects discussed at length (accompanied by pertinent charts)

1. The Tellerette Shape
2. Physical Characteristics
3. Lower Capital Investment and Operating Cost
4. Low Weight
5. Reduced Tower Height
6. Increased Tower Capacity
7. Support Plates
8. Corrosion Resistance
9. No Clogging

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CEP's DATA SERVICE

Equipment *from page 96*

347 Pumps, gear, metering. Technical bulletin from Eco Engineering Co. gives pressure and capacity curves, dimensions, applications, design, features, materials of construction.

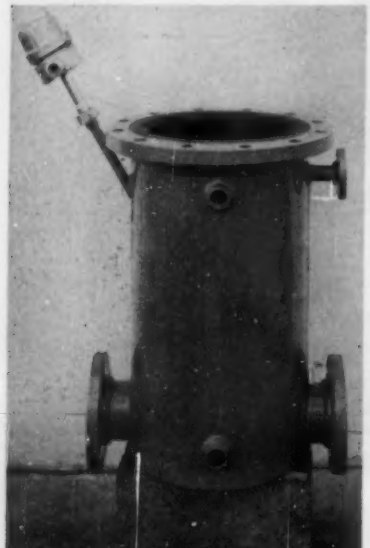
348 Pumps, metering, precision. Only glass and Teflon in contact with solution. For metering strong acids, oxidizers, organic solvents. Data sheet from Harold Kruger Instruments.

349 Pumps, reciprocating. Catalog from Jaeco Pump Co. tabulates 42 standard sizes, gives complete pressure and horsepower data.

350 Pumps, screw. Six-page bulletin from Sier-Bath Gear & Pump Co. outlines construction, operating characteristics, dimensions, capacities, of internal gear and bearing screw pumps.

351 Pumps, sump. Ordering data, installation information, horsepower, dimensions, contained in bulletin from Deming Co. Many charts and tables, also price list.

DEVELOPMENT OF THE MONTH



DATA ON DISTILLATION COLUMN PERFORMANCE

(Circle 600 on Data Post Card)

Distillation Engineering Co. offers a short article which is in effect a condensed bibliography on the effect of continuous versus intermittent reflux on distillation column performance. Also offered is data on steam-jacketed explosion-proof reflux splitters. Shown in illustration is a 12 in. model with a thruput capacity up to 3,000 gal./hour. The splitters are available in all materials and construction in sizes from 2 in. up. For data on these units and a copy of the article on column performance, Circle 600 on Data Post Card.

353 Reactor, continuous. Combines continuous mixing with temperature control. Folder from Baker Perkins, Chemical Machinery Division. Construction details, capacities of the "Flow-master."

354 Regulators, valve. Manual from Rockwell Mfg. Co. gives typical arrangements, line, cutaway, and schematic drawings, characteristic curves.

358 Seals, mechanical, corrosion-resistant. Bulletin from Garlock Packing Co. lists types, optional designs, specifications. Includes application data.

359 Seals, mechanical, floating-ring. Specially-designed for corrosive media at elevated temperatures and pressures to 2,000 lb./sq. in. Brochure from Koppers Co., Metal Products Division.

360 Seals, mechanical. New catalog section from Syntron Co. gives engineering data, specifications on complete line of mechanical shaft seals.

361 Thermocouples. Bulletin from Bristol Co. gives types, materials, sizes, applications.

362 Tubes, filter, porous carbon. Typical configurations include open-end tube, blind-end tube, counterbored-tube, and blind-end tube with collar flange. Dimensions and prices from National Carbon Co.

363 Tubes, meter. New 20-page Catalog Section "D" features specifications of standard meter tubes made by Daniel Orifice Fitting Co. Also data on special materials, accessories, and design information.

364 Tubing. Catalog from J. Bishop & Co. Platinum Works gives types, grades, lengths, finishes, general characteristics, of small-diameter stainless, nickel, and nickel-alloy tubing, glass-to-metal sealing alloys, fabricated tubular parts.

365 Tubing, beryllium-copper, small-diameter. Data Memorandum from Superior Tube Co. gives mechanical and physical properties, applications, corrosion resistance, heat treatment and fabrication data, standard size tolerances.

366 Valves, air-operated. Specifications, construction details, chart of valve sizing coefficients. Bulletin from Conoflow Corp.

367 Valves, automatic, remote-control. Can be turned on or off from any part of the processing plant, either by push button or as part of a pre-time cycle. Details from G & H Products Corp.

368 Valves, check, all-plastic. Available in PVC types 1 and 11, Kralastic, Penton, and Profax, sizes from ½ to 2 in. Technical details from Chemtrol Co.

374 Valves, plug. Illustrated data sheet shows operation of plug valves designed for use at temperatures from minus 40 to plus 250°F, operating pressures of minus 14.7 to plus 150 lb./sq. in. Circle Seal Products Co.

375 Valves, reducing, high-pressure. For large-ratio pressure reductions from 6,000 lb./sq. in. initial pressure to outlet pressures from 100 lb./sq. in. upward. Details from Atlas Valve Co.

377 Valves, solenoid, high-pressure. For controlling air and gases to 2,500 lb./sq. in., liquids to 1,800 lb./sq. in. Full details from Automatic Switch Co.

378 Valves, wafer. Bulletin from S. Morgan Smith Co. gives standard materials of construction, dimensions, allowable pressure drops. Available with metal and rubber seats.

Materials *from page 94*

384 Gases, radioactive. Available with Krypton-85, gaseous Carbon-14, or Sulfur-35 compounds. Data from Matheson Co.

385 Heat Transfer Medium. Bulletin from Dow Chemical Co. describes Dowtherm 209, specifically-designed for use in ebullient cooling.

386 Insulation, industrial. Manual from Aber Co. discusses fundamentals of industrial insulation, with special attention to high and low temperature applications.

387 Polypropylene. Special progress report from American Agile Corp. features detailed charts of properties, plus table of weld values and application information.

388 Resins, polyester. Technical Service Bulletins from Witco Chemical Co. describe polyesters for production of rigid or flexible urethane foams.

389 Resins, water-soluble. Technical data from Archer-Daniels-Midland on Arolon 1000, completely non-flammable resin which retains the properties of organic solvent-thinned alkyd-melamine systems.

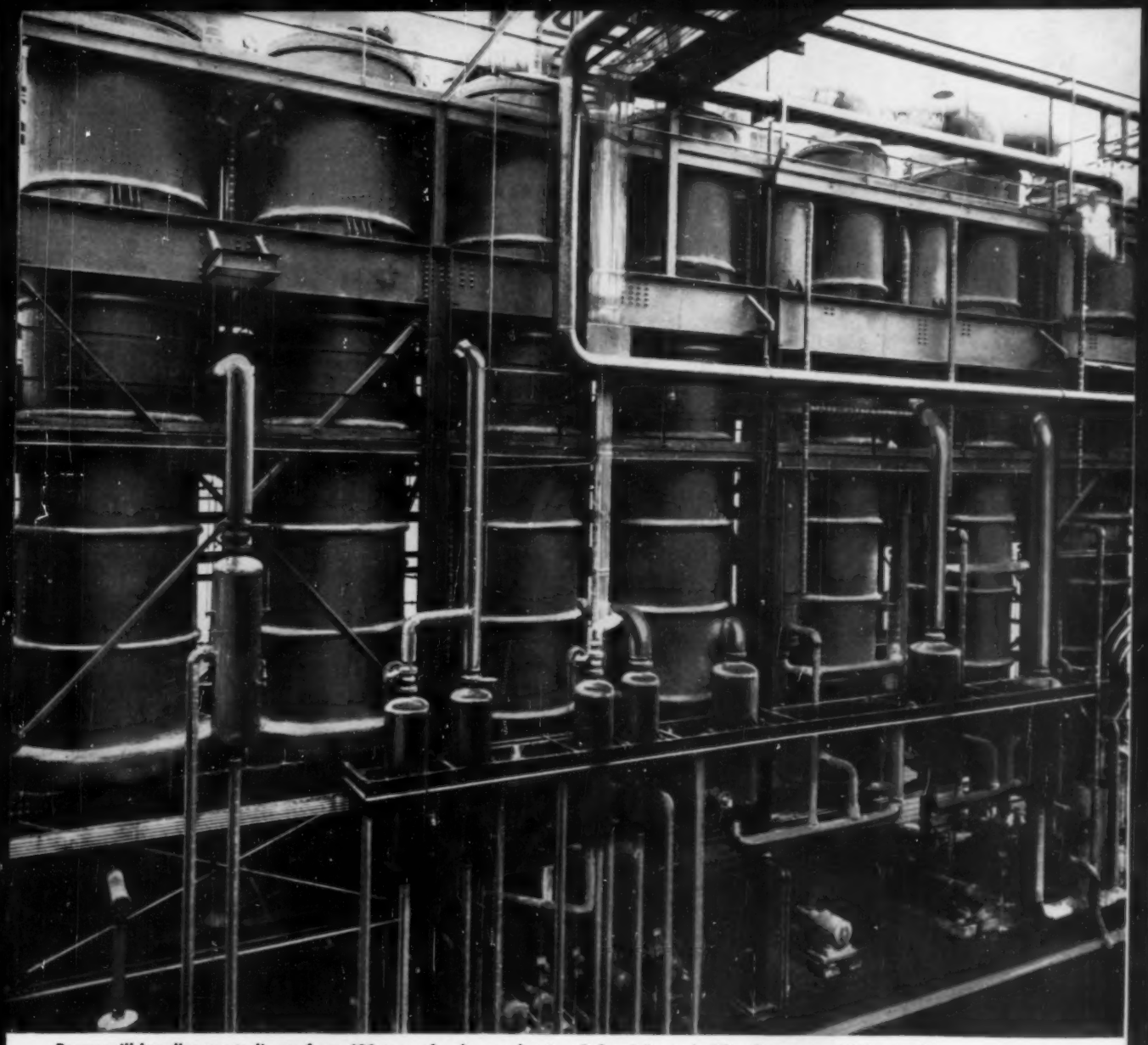
390 Silicone Intermediate. Dow Corning Corp. offers 16 pages of data sheets giving applications, properties, and formulations of its Z-6018, new silicone intermediate which reacts with wide variety of organic resins and monomers.

391 Steels, alloy. Bulletin from Carpenter Steel, Alloy Tube Division, gives sizes, gauges, finishes, chemical composition, mechanical and physical properties of high-temperature, low-expansion, high-permeability alloys.

392 Tri-n-butyl Phosphine (TBP). Technical bulletin (5 pages) with 65 literature and patent references. Food Machinery and Chemical Corp., Chemical & Plastics Division.

393 Wire, thermocouple, ceramic-insulated. In outside diameters from .020 to ½ in., with magnesium, aluminum, or zirconium oxide insulation. Bulletin from Claud S. Gordon Co.

394 Zirconium Hydride. Four-page Technical Data Sheet from Metal Hydrides, Inc. gives physical and chemical properties, application data on Nuclear Grade R and Commercial Grade C zirconium hydride.



Paper mill handles waste liquor from 400 tons of pulp per day in a Buflovak Septuple Effect Evaporator. With a total heating surface of 66,500 square feet, this especially designed unit evaporates 6.3 pounds of water per pound of steam.

Longview Fibre Company cuts steam needs with unique Buflovak Evaporator

Saved: 2,500 pounds of steam per hour in concentrating waste black liquor. In designing and building this giant, septuple effect evaporator, Buflovak engineers used three vapor heat exchangers to lower steam requirements . . . boost operating efficiency.

Waste solids produced by the Buflovak evaporator can be eliminated profitably. Instead of creating a difficult disposal problem these wastes are burned as an auxiliary boiler fuel.

Processing economies like these are typical of Buflovak job-engineered evaporators. Because Buflovak builds a full evaporator line, you are sure of an impartial recommendation based exclusively on your needs.

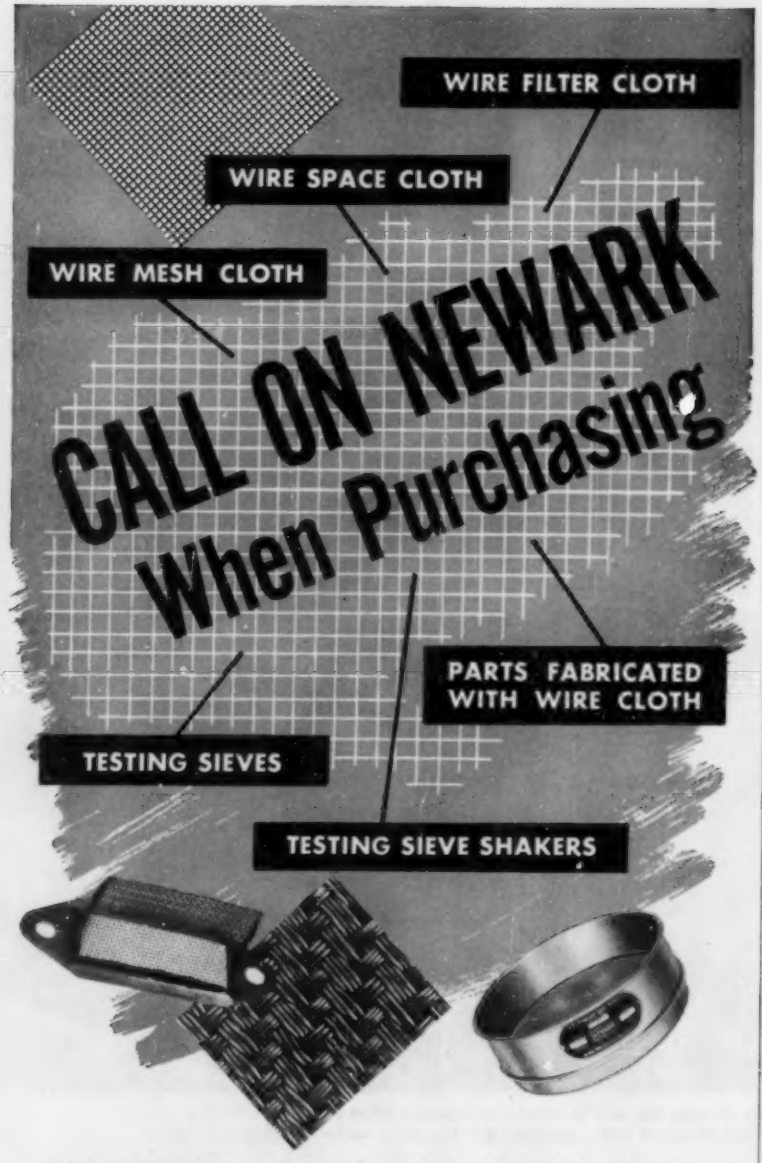
Pre-test your evaporating process in Buflovak's Customer Service Laboratory

This fully equipped research center contains both small scale and pilot size testing equipment. Whether you examine a beaker of material or make a full scale production run, you'll get dependable results, accurate data . . .

Write for Catalog 372 on evaporators. Catalog 381 on the lab. Also refer to C. E. Catalog, pages 429 to 452.

BLAW-KNOX

BLAW-KNOX COMPANY
Buflovak Equipment Division
1567 Fillmore Avenue, Buffalo 11, New York



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New design concepts offer nuclear fuel economies

Reactor control by variable mixtures of light and heavy water, fine particle suspension in gas as coolant, said to show promise.

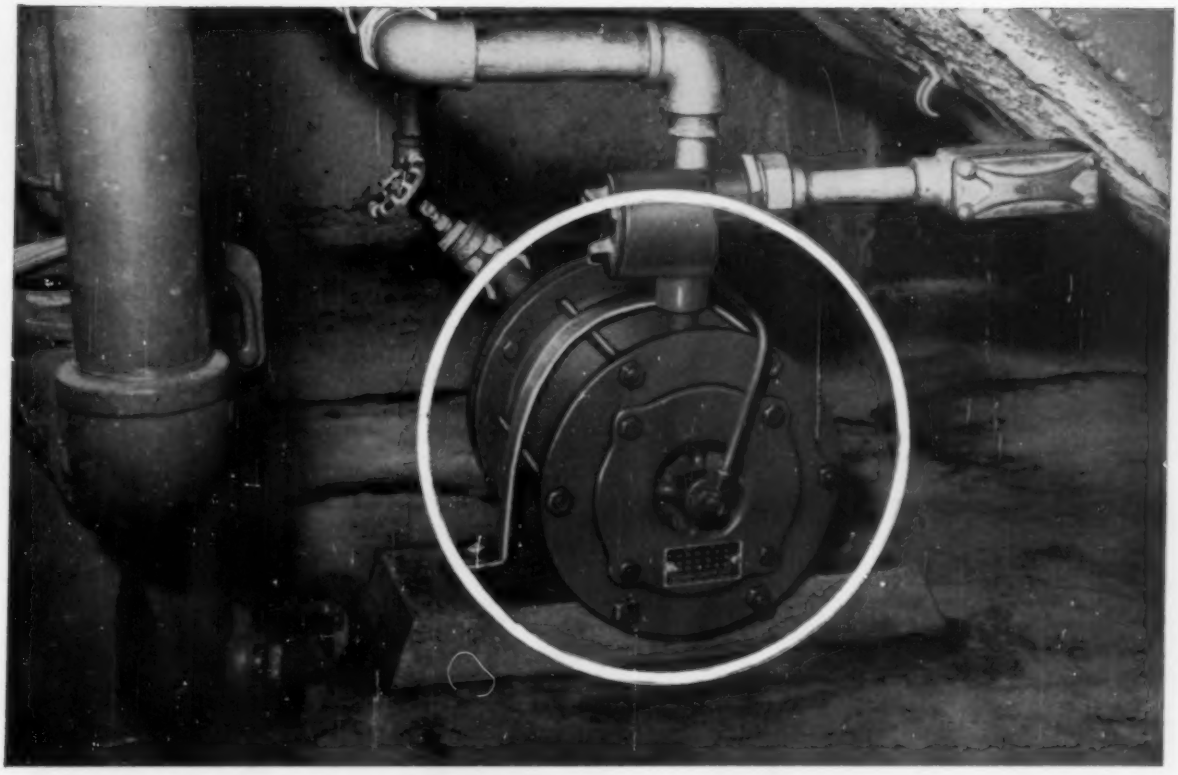
With the AEC calling for industry participation in a research program to reduce fuel cycle costs (page 108, this issue), two new approaches are proposed by Babcock & Wilcox.

The first concept introduces the use of mixed light and heavy water to control pressurized and boiling water reactors. To achieve a core with a long lifetime, the original core must be loaded with a quantity of fuel in excess of that needed to form a critical mass. The excess reactivity must be controlled carefully, and be made available gradually to replace the material being burned up.

In the proposed new control method, instead of the conventional control rods whose use affects adversely the overall efficiency of the reactor, the proportions of heavy and light water in the coolant-moderator are varied. The initial high concentration of heavy water (about 80%) requires more fissionable material for criticality than does the lower concentration (about 30%) used near the end of the core life. Consequently, a large amount of fissionable material can be safely loaded into the core at the outset. Then, during operation, as the fuel burns up, new fuel is made available by diluting the heavy water, since lower concentrations of heavy water require less fissionable material for criticality. Such a "Spectral Shift Controlled" Reactor, according to B & W, promises to extend the life of a core to as much as 40,000 megawatt days per ton of fertile material, more than twice that expected from a conventional pressurized water reactor.

Concept number two is based on recent experimental data which indicate that the heat transfer and heat transport properties of gases are improved greatly by suspending fine particles in the gases. Such a gas-suspension reactor coolant would consist of fine particles (less than 5 microns) of graphite or other solids suspended in carbon dioxide, nitrogen, helium, or argon. The density of these mixtures would vary between 5 and

continued on page 102



Chempump eliminates fire hazard

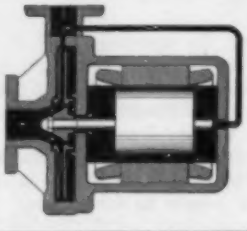
handling acetone and naphtha at Vi-Jon Laboratories

This *Chempump* moves a highly inflammable mixture of acetone and naphtha in the manufacture of chemical specialties and cosmetics at Vi-Jon Laboratories' St. Louis plant. The conventional pump it replaced leaked continually at the packing gland, creating a fire hazard. The leakproof *Chempump* solved this serious problem.

For Vi-Jon Laboratories, *Chempump* means maintenance economy as well as safety. The company reports there has been absolutely no maintenance on the pump. "It was installed and forgotten, as far as maintenance is concerned."

With *Chempump*, hard-to-handle fluids can't leak—in or out—because there are no seals, no stuffing box, no packing. Occasional inspection and replacement of bearings is the only care required. External lubrication is never needed—bearings are constantly lubricated by the pumped fluid itself.

Leakproof fluid handling with *Chempump* offers many other advantages well worth your investigation. For details, write to Chempump Corporation, 1300 East Mermaid Lane, Philadelphia 18, Pa. Engineering representatives in over 30 principal cities in the United States and Canada.

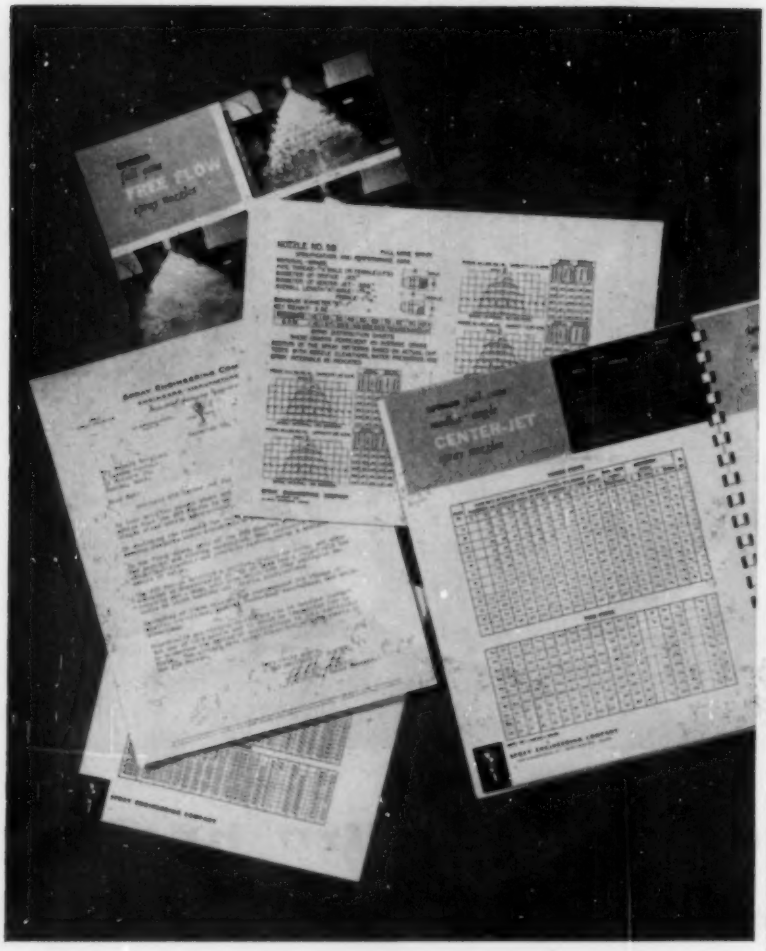


Chempump combines pump and motor in a single, leakproof unit. No shaft sealing device required.

U.L. approved. Available in a wide choice of materials and head-capacity ranges for handling fluids at temperatures to 1000 F. and pressures to 5000 psi.

Chempump

First in the field...*process proved*



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Here's a surer, easier way to specify spray nozzles

How can you be sure you're specifying the *right* spray nozzle for your particular application?

Spraco's research department has taken the guesswork out of this problem by preparing complete and accurate performance data for each of the hundreds of spray nozzles in the Spraco line. Each nozzle "profile" is complete with data on material, dimensions, flow rate, pressure, angle of spray . . . everything you need to enable you to choose, at a glance, the nozzle that will deliver maximum performance and efficiency in your particular application.

No matter what your spray nozzle problem, Spraco makes this information available to you absolutely free. Why not write and ask about it — today?

SPRAY ENGINEERING COMPANY

132 Cambridge Street, Burlington, Mass.

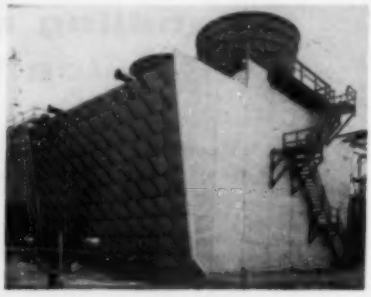
SPRACO

Nuclear fuel economies

from page 100

15 lb./cu. ft. at an operating pressure of 100 lb./sq. in. gauge or less.

Preliminary experimental work at Babcock & Wilcox has been done largely with graphite-CO_2 mixtures with densities up to 8 lb./cu. ft., circulated in a 3/4 in. IPS closed loop at 35 lb./sq. in. gauge, 300°F, and 40 ft./sec. No evidence of erosion or significant particle adherence to surfaces has been remarked, and it is said that heat transfer rates increased by a factor of eight over that for CO_2 alone at the same pressure, temperature, and velocity. In addition, heat transported around the loop is reported to be increased by a factor of 21. It is calculated that the improved heat capacity of the coolant would permit an increase in reactor inlet temperature to 487°F (as compared with 275°F at Calder Hall), and would eliminate the need for economizers and the two-pressure boiler system. Moreover, the possibility of extracting a higher temperature steam would result in a higher feedwater temperature and a significant improvement in steam cycle efficiency. Bonus would be an important reduction in the size and cost of primary piping, etc.



Of new and original design is this alkylation-area cooling tower at Esso's Baton Rouge, La. refinery. Believed to be the first commercial application of the new design, the tower has an exterior of widely-spaced large asbestos cement louvers. The unusually tall fan stacks at the top of the tower (14 ft.) are said to reduce the amount of horsepower needed to pull air through the tower. Design and erection were by Marley Co., Kansas City.

A process for bonding vinyl plastic sheet to metal on a continuous basis has been licensed by United States Rubber to Nakanoshima Steel, a division of Yawata Iron and Steel Co. Japan's largest steel firm. Nakanoshima will produce the laminate in sheet form for supply to fabricators.

Three new Girdler-built hydrogen plants put the zip in high-energy fuels

METAL HYDRIDES: Recently built Girdler plant supplies high-purity hydrogen for the Navy's large-scale sodium borohydride plant operated by Metal Hydrides, Inc., at Danvers, Massachusetts.

CALLERY CHEMICAL: Another hydrogen plant is part of facilities now being constructed by Girdler for the Navy's HiCal* high-energy fuel plant... a project of Callery Chemical Company at Muskogee, Oklahoma.

OLIN MATHIESON CHEMICAL: And now, a third Girdler hydrogen plant is under construction... part of the high-energy fuel plant being built for the Air Force by Olin Mathieson Chemical Corporation at Model City, New York.

These three plants provide further evidence of Girdler's unsurpassed experience in hydrogen plant construction. Call on our services to help in your planning of new or expanded facilities.

GIRDLER CONSTRUCTION DIVISION

CHEMETRON CORPORATION

Louisville 1, Kentucky

Sales Offices: New York, N. Y. San Francisco, Calif.

CHEMETRON

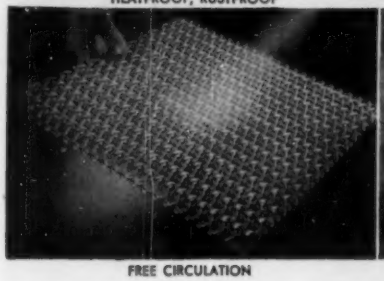
Girdler-built hydrogen plant at sodium borohydride plant of Metal Hydrides, Danvers, Massachusetts.

New Hydrogen Book. *Latest techniques for production, purification uses. Free on request.*

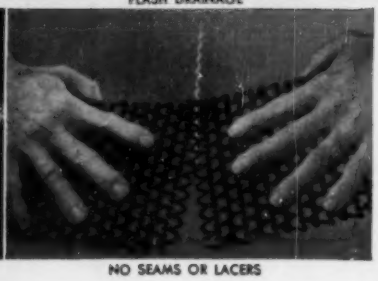
Cambridge WOVEN WIRE BELTS

HEATPROOF, RUSTPROOF

FLASH DRAINAGE



FREE CIRCULATION



NO SEAMS OR LACERS

METAL-MESH BELTS GIVE FAST, UNIFORM PROCESSING AT LESS COST

Whether you process slab, sheet or pelletized materials through wet, dry, hot or cold operations, Cambridge belts can combine movement with processing to give you increased production, and higher product uniformity at lower operating costs. Here's how:

CONTINUOUSLY MOVING BELTS ELIMINATE BATCH PROCESSING—give faster, less costly production; reduce slow, costly manual handling.

OPEN MESH PROVIDES FREE AIR, LIQUID CIRCULATION—atmospheres and solutions circulate through the belt and around product for fast, uniform processing, flash drainage. Close mesh can't mar or mark soft slab or sheet products.

ALL-METAL CONSTRUCTION IS HEATPROOF, COLDPROOF, RUSTPROOF—Cambridge Belts can be woven from any metal or alloy to take up to 2100° F. or sub-zero temperatures, yet remain impervious to attack from water, acids or caustic solutions.

SPECIAL SURFACE ATTACHMENTS AVAILABLE—raised edges and cross flights to keep product on belt during movement.

Currently, Cambridge Belts are used in the chemical industry for such diversified operations as bagging cement, drying wool, cooling and drying polyethylene sheets, washing, rinsing and drying catalysts, tanning hides, drying coal, and processing rubber.

Talk to your Cambridge Field Engineer soon. He'll recommend the belt size, mesh or weave—in the metal or alloy best suited to your operations. You'll find his name in the classified phone book under "BELTING-MECHANICAL". Or, write for FREE 130-PAGE REFERENCE MANUAL giving mesh specifications, design information and metallurgical data.

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OFFICES IN PRINCIPAL INDUSTRIAL CITIES

Automation, larger throughput, trend in modern separators

Stig Beskow, technical director, and Ove Kjellgren, manager Industrial Technical Division, of A. B. Separator, Stockholm, Sweden, were interviewed at a brief press conference held by De Laval Separator Co., in New York recently.

A. B. Separator is the world headquarters organization for De Laval centrifugal separators. As such it coordinates the development, design, manufacturing, and applications engineering activities of the various De Laval companies in many countries. Present with the gentlemen from Sweden was F. E. Sullivan, manager Industrial Engineering Dept. of The De Laval Separator Co., Poughkeepsie, N. Y.

The trend, according to these men, is towards larger centrifugal machines; 400 gal./minute throughput, and 50 h.p., is not uncommon today. Automated operation is also highly desired; this, in the case of solids-liquid separators, means continuous solids discharge.

The variety of machine types required by the chemical process industries has risen sharply since the war. To simplify production, and achieve economies necessary to make the application of centrifugal force successfully competitive, the De Laval group have standardized various frame, bowl, power drive, and other components. So far as possible, the machine for the given application is tailored from such standard parts.

The European chemical engineer, or industrial chemist, is more aware of the advantages of centrifugal separation than his American counterpart, according to the Swedes. In some industries, notably petroleum refining, the European plant is more likely to make preferential use of centrifuges, but in the case of this one industry the explanation is simply a matter of scale. Smaller European refineries have found the conventional sizes of centrifuges readily adaptable to their processing needs. With the larger machines, the De Laval people no doubt have an eye on the giant refinery market of the U.S.

The development of the pressurized centrifuge, in which the bowl is completely filled with liquid, is said to

continued on page 106

Applying Cryogenics to solve your process problems

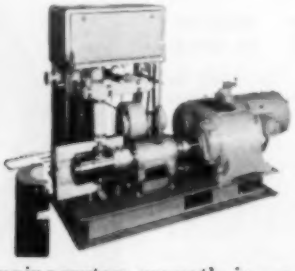
THERE IS NO SUBSTITUTE FOR *Air Products* INTEGRATED EXPERIENCE...

PROCESS RESEARCH

Process research begins with the collection and analysis of fundamental information about the behavior of materials in all types of environments.

At Air Products, process research is not limited to cryogenic systems and processes. The effective use of low temperature processes depends upon their proper integration with all prior and subsequent steps.

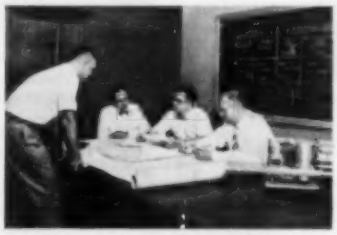
Each processing problem is accepted as a new challenge. It is not unexpected for identical feed gases to be processed in entirely different ways to meet diverse objectives. Pilot-type experimental systems are frequently used in this work as an intermediate evaluation tool.



EQUIPMENT DEVELOPMENT

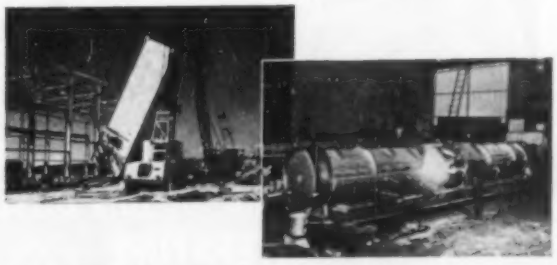
Here is shown a new pumping system currently in production for pumping large quantities of liquid oxygen at 6000 to 12000 psi.

Air Products is constantly developing new types of equipment and improving existing designs to meet new problems.



PROCESS DESIGN

Working from a broad base of fundamental and applied data and from operating experience, Air Products' process designers are accustomed to optimizing cost factors in processes which are dependable, controllable and reliable. This creative phase of the technical function utilizes knowledge gained in all areas of cryogenic experience.



EQUIPMENT MANUFACTURE

Years of equipment manufacture at Air Products have resulted in the highest standards for manufacturing methods and procedures, quality control testing and equipment maintenance. Long experience in project management has resulted in strong feedback to basic design groups, aiding significantly in the design of practical, reliable processes and equipment.

PLANT OPERATION

The day-to-day operation of the many and varied low temperature processes under the direct supervision of Air Products' Operations Department provides strong guidance to all our technical people. Living with the equipment one builds has a highly desirable effect on standards of manufacturing excellence.

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A letter, a wire or a phone call to Air Products will quickly bring you the services of an experienced cryogenics engineer who can help you interpret the potential contribution of applied cryogenics to meet your needs. A vast storehouse of information may be put to your use instantaneously for:

1. Evaluation of existing processes to suit your specific needs.
2. Development and adaptation of new processes as required.
3. Over-the-fence supply of almost any gas on a guaranteed cost basis.

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INDIVIDUAL .....

ADDRESS .....

CITY ..... ZONE ..... STATE .....

Separators

from page 104

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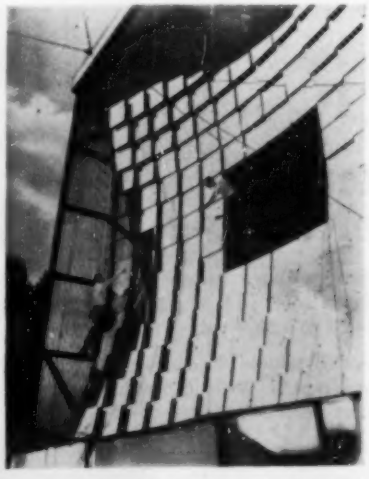
A. B. Separator also makes plate-type heat exchangers, and has recently gone into production with some unusually large ones for a French Guiana alumina plant where the liquid volume throughput requirement is of the order of 40,000 gal./hr. To press the thin, corrugated stainless steel plates, A.B.S. made use of the giant hydraulic press normally used to press body sheets for the well-known Volvo Swedish car.

A good many of the more complex separators sold in the U.S., as well as throughout the world, are actually made in Sweden, according to Beskow. One of the latest developments of which the firm speaks proudly, is a recent design in which the auxiliary pump impellers are coupled directly to the centrifuge drive shaft, permitting the entire unit to operate with one motor.



A giant step in the race to harness the sun is this solar furnace at the Quartermaster Research & Engineering Command (U.S. Army) in Natick, Mass. Although designed for high thermal flux, rather than high temperature, a sample exposed to the furnace's concentrated energy should reach 5,000°F. at the image position. This is said to simulate closely the thermal radiation which would be received by materials or personnel in the vicinity of nuclear-weapon explosions. The installation is composed of 180 spherical mirrors, each 2 by 2 ft., made to an exact curve by a special "slumping" technique. Manufacturer is the American Optical Co.

ALLIS-CHALMERS

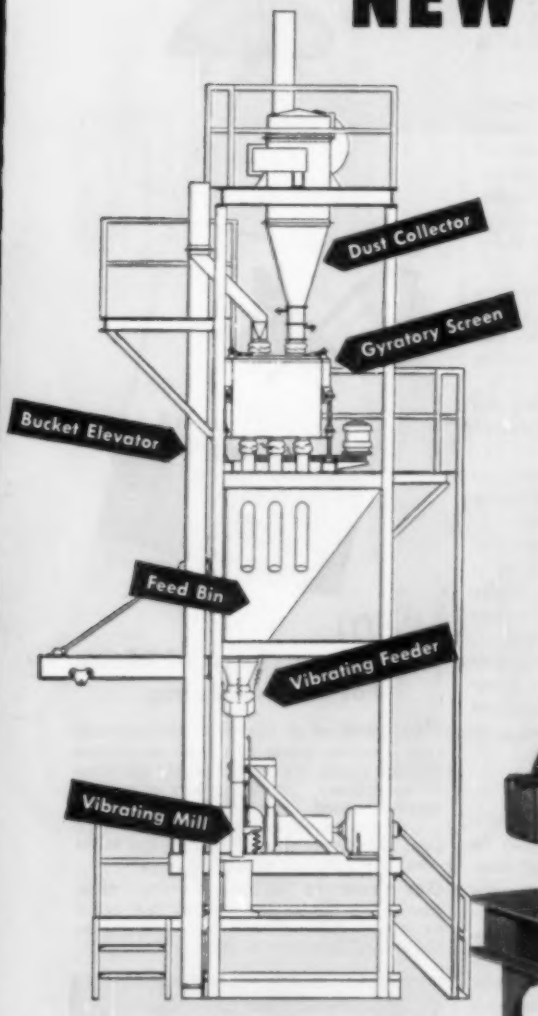
NEW grinding plant

15 to 30 times more capacity
50% less space required

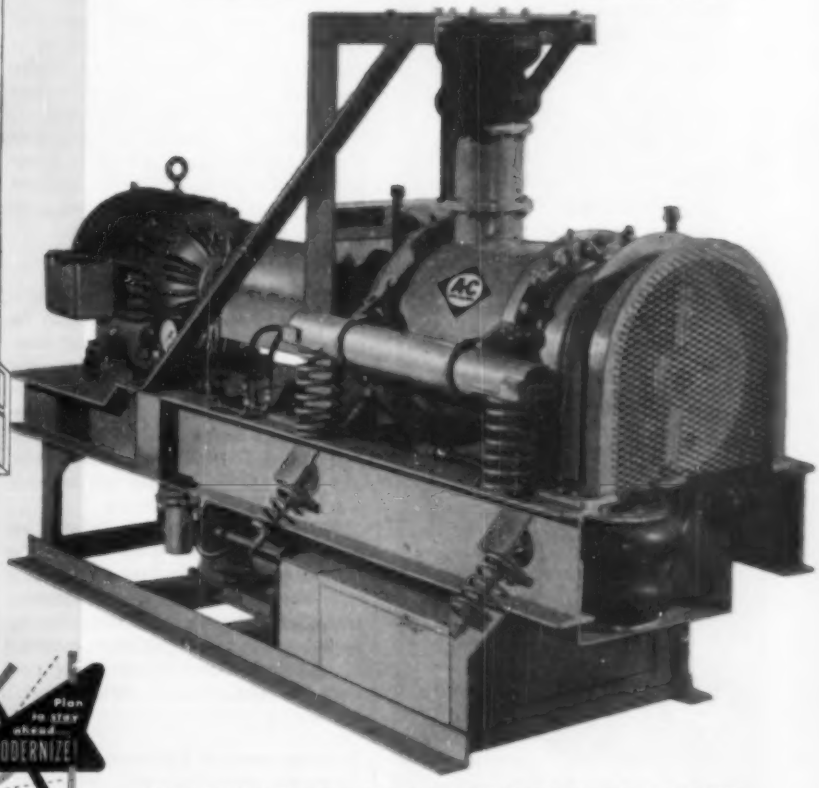
a complete "package" — at a surprisingly low cost

You can now process as much as one ton per hour of dry materials within less than 127 square feet of floor space with this new Allis-Chalmers Grinding Plant. Plant components are designed, applied and "coordineered" to handle materials in a 30 to 300 lb per cu ft range. Vibrating mill out-produces a tumbling mill 15 to 30 times per unit volume. The plant is a complete pre-engineered "package" that affords the low price tag of an off-the-shelf item, and built-in flexibility offers tailored-to-the-job performance.

Operating economy, accessibility, cleanliness and easy maintenance of the entire plant are other advantages.



Plant includes structural steel, platforms, ladders and processing equipment, motors, and drives — everything match-marked for convenient erection.



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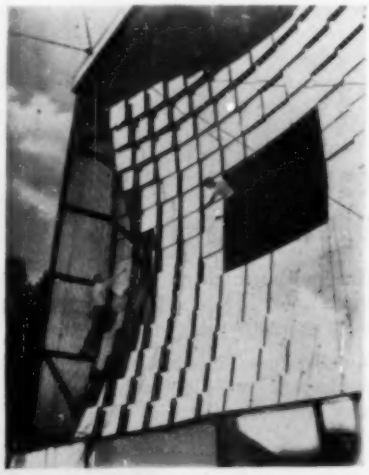

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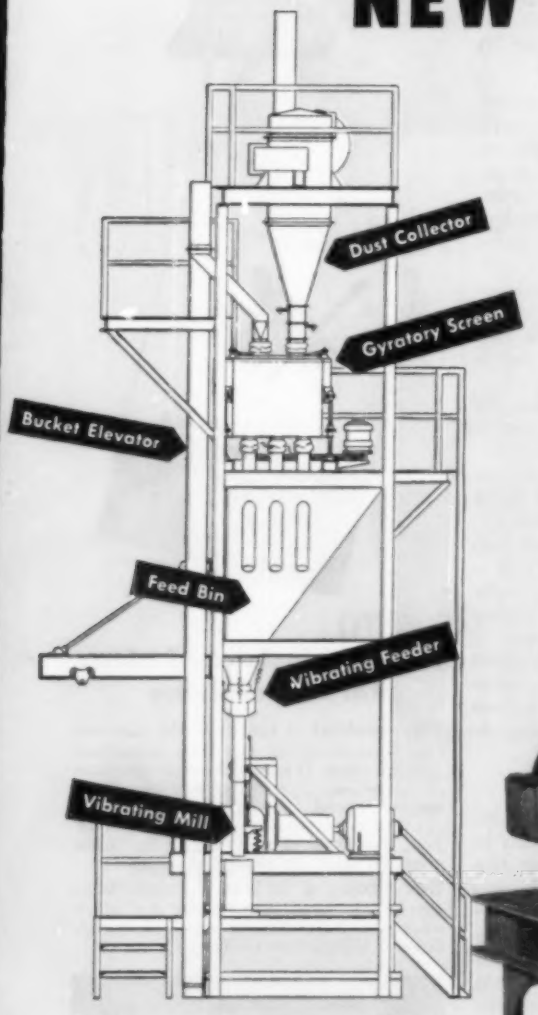

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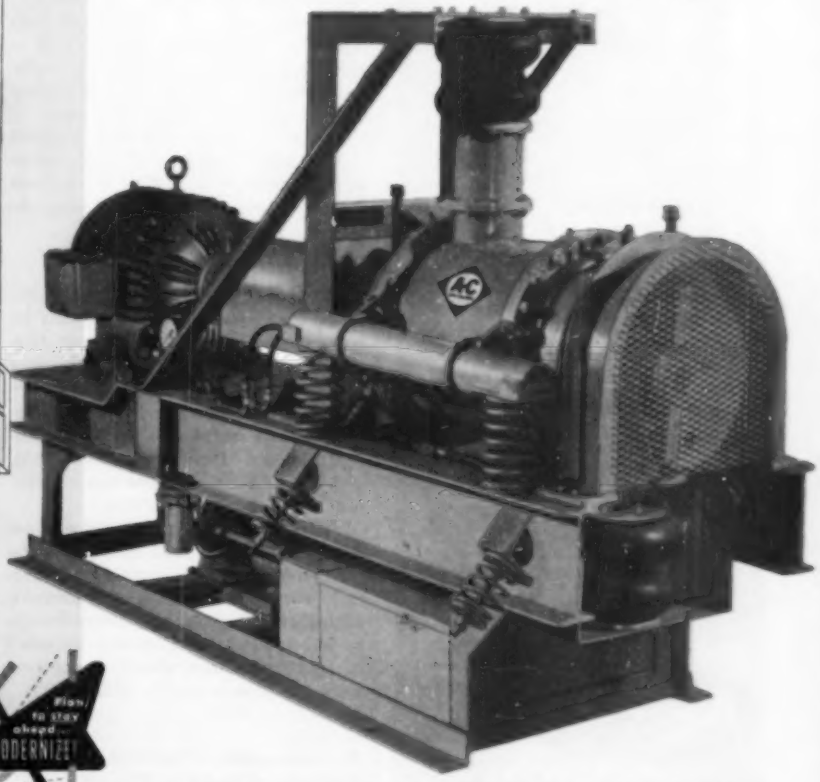

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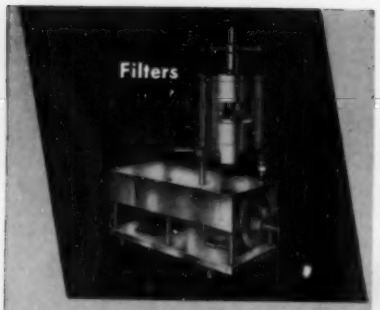

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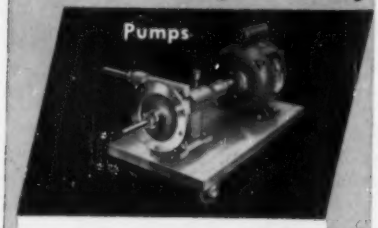

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AEC challenge to chemical industry— lower nuclear fuel costs

Chemical processing, reprocessing, and fuel element cost can be drastically reduced says AEC, inviting industry to participate in new research program.

The chemical industry is expected to play a major role in a new research and development program announced by AEC. Aimed at the substantial reduction of overall power reactor operating cost, the Fuel Cycle Development Program will embrace these major areas:

Development of chemical processes related to the total fuel cycle;

Development of fuel element materials and designs suitable for use in power reactors;

Irradiation and post-irradiation examination of selected fuel element materials;

Development of fabrication and inspection techniques which will lower fuel element manufacturing costs;

Development, fabrication, and testing of prototype fuel elements of a variety of promising types, especially those capable of operating at higher temperatures and higher burnups;

Selection of proven fuel element types and fabrication of large numbers of these elements for subsequent use as multi-ton batches in full-scale power reactors.

Flexible contracts

The type of contracts to be negotiated under the new program may be cost, cost-plus-fixed-fee, or cost-sharing, says AEC, depending on the scope of the work. AEC assistance may include provision of hot cell facilities and irradiation space in test reactors, and arrangements for obtaining space for operational use in commercial-size power reactors.

No limitation has been placed on design or type of fuel elements to be developed, or on the fissionable material to be used in such elements. However, all proposals must be directed toward a significant lowering of fuel cycle costs. Deadline for proposals is November 28, 1958.

Nuclear needs of Euratom, and other European countries, will be served by Westinghouse International Atomic Power Co., recently established in Geneva, Switzerland.

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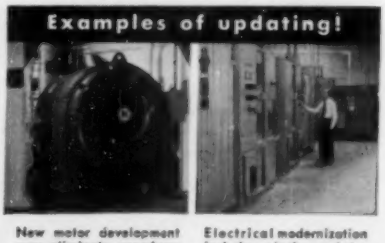
NEW brochure of ideas for modernizing

This booklet is based on the premise that modernization can start anywhere in your plant. It can be a single machine or operation . . . a better way of getting variable speed . . . a faster way to braze . . . or a newly available replacement. In fact, this type of updating is far more common than the sweeping change.

Get a copy of "59 ideas for modernization in '59" from your nearby A-C office or write Allis-Chalmers, Industries Group, Milwaukee 1, Wisconsin.



New motor development may eliminate premiums you've been paying for specially protected motors.

Electrical modernization includes placing substations close to machines being served.

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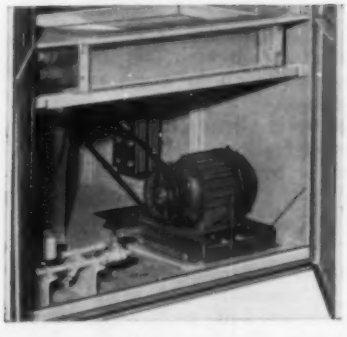
Two 100-kw, 250-volt silicon rectifiers installed in industrial service. Semi-conductor rectifiers are simple in operation and maintenance, require little floor space.



Effective cooling — closed recirculating air system features air-to-water heat exchange and delivers same amount of cooling air to each diode. Air is sealed in. Direct air cooling system also available.

Only application experience like this can give you highest conversion efficiency

High power conversion efficiency at low cost is the major advantage of the semi-conductor rectifier. But this high efficiency — as high as 95% — can be obtained only when the unit is *correctly applied*.

Allis-Chalmers 30 years of experience in developing, manufacturing and *applying* rectifiers assures you of the highest conversion efficiency. This background of experience, plus vast research and engineering facilities, is available for a thorough analysis of your requirements. Then, specific, unbiased equipment recommendations are made — dictated solely by your requirements — because Allis-Chalmers makes all types of rectifiers.

Every semi-conductor rectifier installed by Allis-Chalmers has performed to the complete satisfaction of the user. Your local A-C man can tell you how a semi-conductor rectifier can be applied profitably to your operations. Call him. Or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin.

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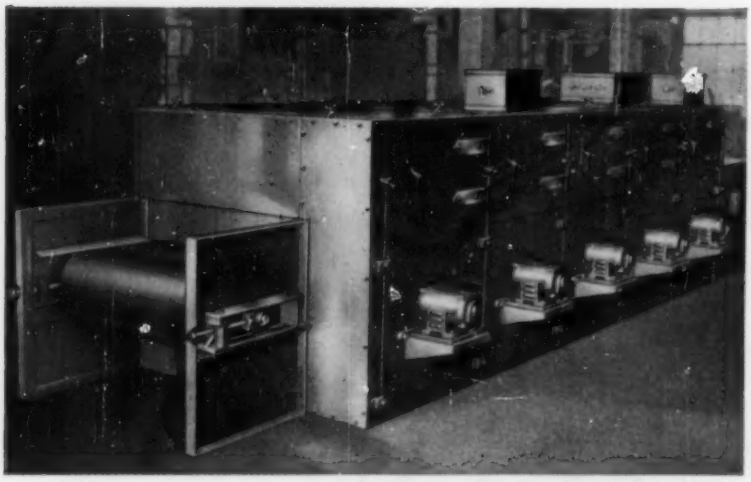
THE FLEXIBILITY OF A LAB DRYER
THE DEPENDABILITY OF A PRODUCTION DRYER



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DETROIT 27 — Clifford Armstrong Co., 16187 Grand River Ave.
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CHARLOTTE, N.C. — W. S. Anderson, Carolina Specialty Co.
ATLANTA, GA. — J. R. Angel, Mortgage Guarantee Building
TORONTO 1, CAN. — Hugh Williams & Co., 27 Wellington St. East

"Chemical engineering holds one of the keys to Utah's future development" said Governor George D. Clyde of Utah, speaking at A.I.Ch.E's recent National Meeting in Salt Lake City. Shown here with Governor Clyde (right) are A.I.Ch.E. president George E. Holbrook (left) and E. B. Christiansen (center), chairman of the technical program committee for the Salt Lake Meeting.

Elmore S. Pettyjohn has been appointed professor of chemical engineering at Fenn College. Prior to joining Fenn, Pettyjohn was president of Gas Associates, N.Y., and has acted as consultant for Gas Machinery Co. for the past year.

D. H. Killeffer, chemical public relations consultant, has moved his headquarters from Tuckahoe, N.Y., to Clearwater, Florida.

New assistant director of Atlas Powder's chemical engineering department is **John W. Hoopes, Jr.** Hoopes, who came to Atlas in 1955, was formerly assistant professor of chemical engineering at Columbia Univ.

A grant for research into the solion principle has been made to **Louis Madonna,** chairman of the chemical engineering department at the University of Ottawa. The grant comes from the Society of Sigma Xi, a professional organization which promotes research activities in the U.S. and Canada.

Malcolm M. Renfrew becomes professor of chemistry and head of the department of physical sciences at the University of Idaho. Renfrew has been director of research and development for Spencer Kellogg & Sons, Buffalo, N.Y., since 1954, and formerly served in similar capacities for Du Pont and General Mills.

continued on page 112

ALLIS-CHALMERS

Standard inclined screens . . . up to 5 inches. (Shown with air springs.)

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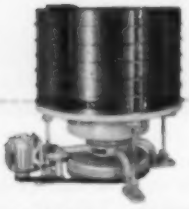
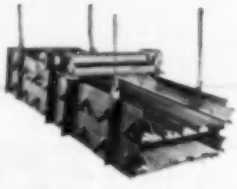
world's most complete line!

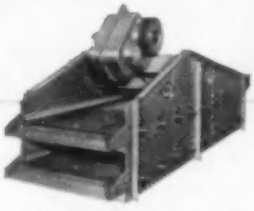
separations from 12 inches to 325 mesh



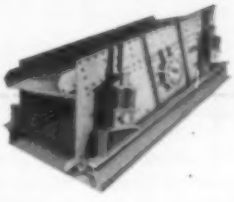
All-metal gyratory screens . . . 2 to 325 mesh.



Small inclined vibrating screens . . . 1½ inches to 40 mesh.



Horizontal vibrating screens . . . up to 2½ inches.



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Expert application help. Allis-Chalmers not only offers the most complete line of dependable, high-production screens, but also provides expert counsel based on unequaled experience in screen applications. In addition, modern pilot plant facilities are available for test runs of difficult or untried materials, if necessary.

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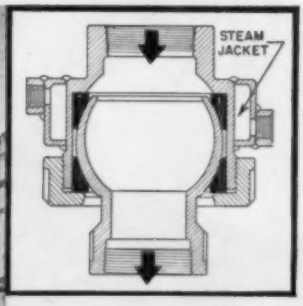
Barco Steam Jacketed Flexible Ball Joints



User reports- "In Service 38 Months -NO MAINTENANCE!"

MOLTEN SULFUR — These photographs show unloading of molten sulfur at Mississippi River dock of National Lead Company, Titanium Division.

UNLOADING LINE
Heated for Free Flow!

HOT steam is the secret of handling sulfur as a liquid at barge loading and unloading docks. Barco's 6" Steam Jacketed Flexible Ball Joints are an integral part of the splendidly engineered installation shown above. A traveling crane raises and lowers pipe made flexible with Barco Joints. This arrangement accommodates river stages varying up to 40 feet. This permanent, maintenance-free, labor-saving installation eliminates the problems of rapid deterioration and frequent maintenance encountered with hose.

For recommendations on how to use Barco Flexible Ball Joints in loading lines handling oil, chemicals, gasoline, alcohol and other fluids, ask for a Barco engineering field representative—located in principal cities.

FEATURES

COMPLETE LINE — Barco Steam Jacketed Flexible Ball Joints are now offered in 2", 3", 4" and 6" sizes.

TO MEET YOUR NEEDS — Straight and angle; screwed and flanged styles. Steel casing.

FLEXIBILITY — The ball provides more than 30° total angular movement in any direction.

VERSATILE—For handling sulfur, asphalt, and other heavy materials. Heat speeds flow; cuts loading time.

ENGINEERING RECOMMENDATION—Ask for a copy of new catalog 2158 on "Barco Flexible Ball Joints for Piping."

BARCO ANNIVERSARY 50

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people in management & technology

from page 110

Joseph H. Vergilio, chemical engineer in the Project Evaluation Research Dept. in the Texaco Research Center, Beacon, N.Y., is co-patentee of a recent patent involving a process for treating carbonylation products.

Hamnett P. Munger, chairman of the Department of Chemical and Metallurgical Engineering at Syracuse University, named head of the Metallurgical Division at Republic Steel's new Research Center in Independence, Ohio. Munger organized and was the first chairman of the Syracuse Section of A.I.Ch.E.

Petroleum Chemicals, Inc., New Orleans, has appointed **Robert L. Hellwig** head of the engineering section in the research division of its Development Department. Hellwig was formerly a chemical engineer for Du Pont, Orange, Texas, and a process engineer for Ethyl Corp., Baton Rouge.

New technical staff member at Thompson-Ramo-Wooldridge Products Co. is **James W. Lane,** formerly a process engineer in operations analysis at Union Oil of California.

Two promotions are reported from Humble Oil & Refining, Baytown, Texas. **D. C. Clark, Jr.,** becomes staff engineer in the technical division, and **H. G. Schutze** will be research associate in the research and development division.

John R. Bowman, associate dean of the Technological Institute of Northwestern University and professor of science engineering, has been named chairman-elect of the Board of Trustees of the Gordon Research Conferences. Winner of the A.I.Ch.E. Professional Progress Award (1954), Bowman was associated for many years with Mellon Institute, where he served as director of research from 1954 to 1957.

James W. Shackelford becomes manager of Arkansas Louisiana Chemical's chlorine plant at Pine Bluff, Ark.

Paul S. Brallier, technical assistant to the president of Stauffer Chemical, has retired after almost 42 years of service with Stauffer and with Niagara Chemical, which became part of Stauffer in 1930.

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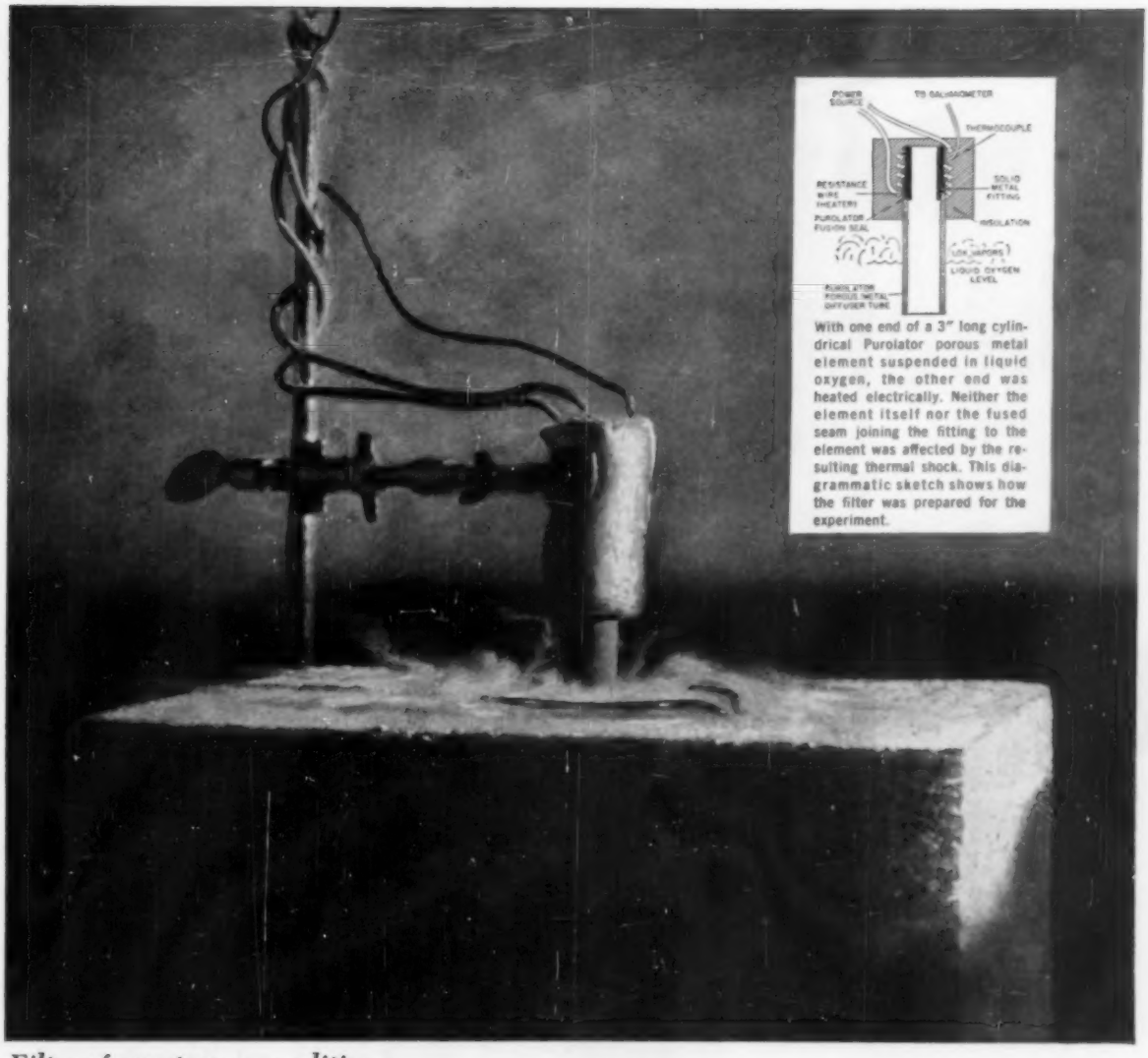

With one end of a 3" long cylindrical Purolator porous metal element suspended in liquid oxygen, the other end was heated electrically. Neither the element itself nor the fused seam joining the fitting to the element was affected by the resulting thermal shock. This diagrammatic sketch shows how the filter was prepared for the experiment.

Filters for extreme conditions . . .

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How much thermal shock can a filter withstand?

In a recent series of experiments, various samples of Purolator metal filter media stood up under temperature gradients, across short lengths, of up to 500°F...and could have taken more. There was no effect on filter efficiency.

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No other filter manufacturer can offer such complete services to handle so wide a range of tough operating conditions. These brochures outline what Purolator can do for you, or, if you have an urgent filtration problem, call Jules Kovacs, Vice President in charge of Technical Sales... or send him the details of your application.

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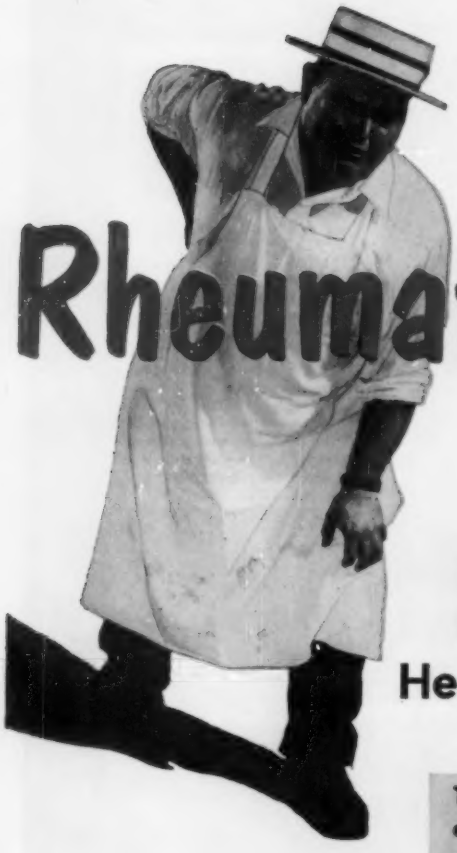

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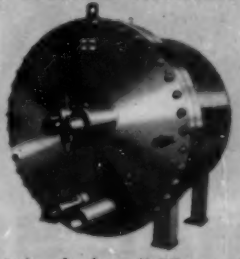

Exterior of a large Heliflow used on an atomic project.

Special Heliflow coil showing how Heliflow can "twist" and relieve temperature strains.

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from page 112

New members of Union Carbide Chemicals' Development Department in South Charleston, West Va., are **Howard M. Bartlett, Donald H. Sargent, Donald W. Simroth,** and **Dodson C. Webster.**

In Atlas Powder's chemical engineering department, **Robert H. Bugel** has been named manager of the process engineering section, and **George E. Woods** becomes assistant manager of the pilot plant section at the firm's chemical engineering laboratories, south of Wilmington.

Leland W. Blazey, formerly with Merck & Co., has been named director of the newly-created Engineering Division at McNeil Laboratories, Philadelphia.

Herman E. Bakken, vice-president of Aluminum Co. of America and general manager of the firm's refining department, has retired after nearly 40 years of service. He is succeeded by **J. Ranald Fox,** formerly assistant manager of the division.

C. J. Wilson, has joined B-I-F Industries, Providence, R.I., as an Eastern regional engineer. Wilson's experience includes service with Union Oil, Griscom-Russell Co., and C. F. Braun Co.

Charleston Rubber Co., Charleston, S.C., announces appointment of **John J. Keilen, Jr.,** as director of research and development. Keilen comes to Charleston Rubber from West Virginia Pulp and Paper, where he was director of development for the polychemicals division.

W. Roberts Wood, vice-president of Chemetron Corp. and president of its Girdler Construction Division, has been elected president of the Louisville, Ky., Chamber of Commerce for 1959.

Louis W. Munchmeyer, assistant general manager of the Michigan Alkali Division Wyandotte Chemicals Corp., has been elected vice-president of the company in charge of industrial chemical manufacturing. Munchmeyer came to Wyandotte in 1955 from General Aniline and Film.

Monsanto Chemical has appointed **James C. Barnett** as manager, technical service, food and dentifrice industries, at its Inorganic Chemicals Division in St. Louis.

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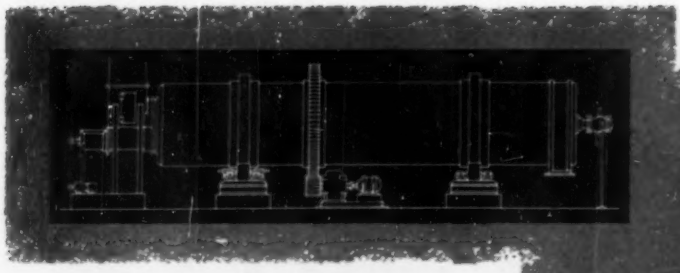

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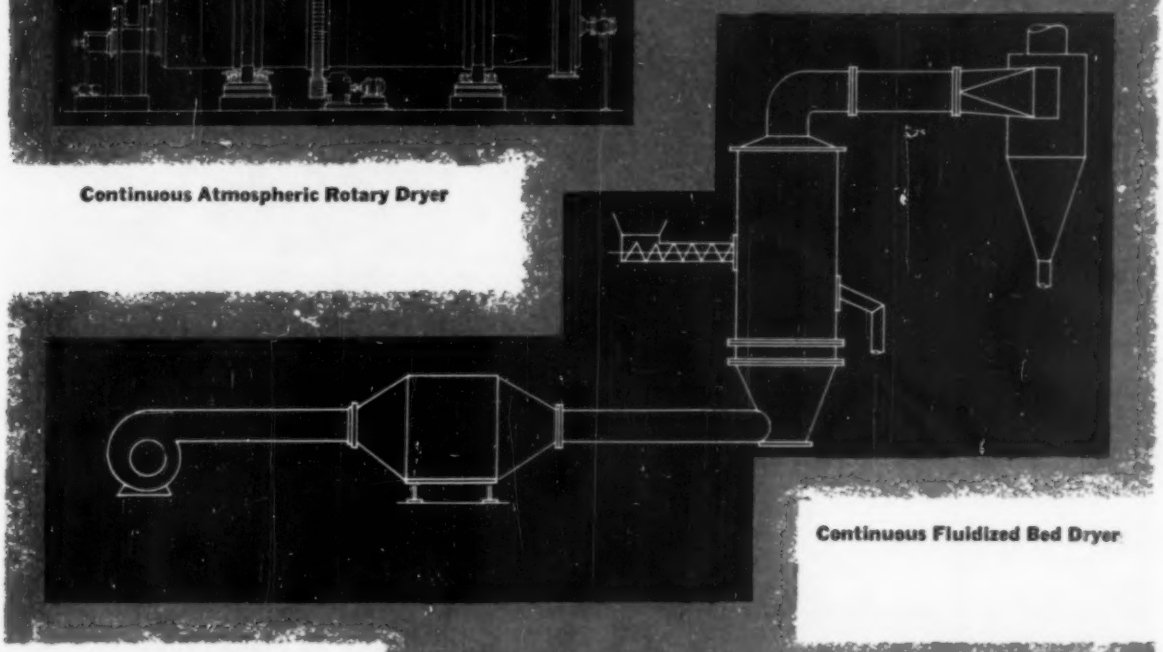
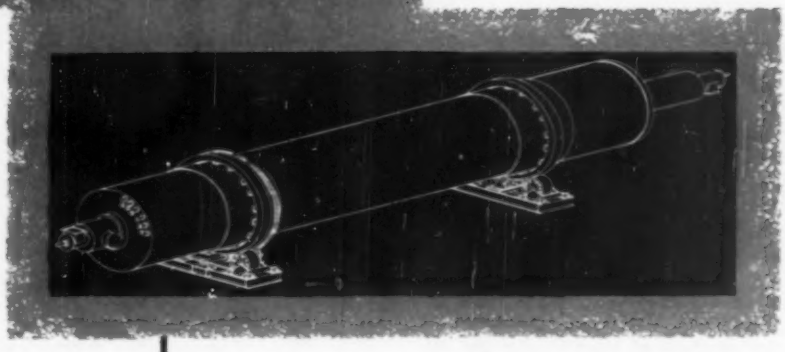


Continuous Fluidized Bed Dryer

Continuous Solvent Stripper
Continuous Gas Solids Reactor
Continuous Vacuum Dryer



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CINCINNATI—Dec. 7-10—final arrangements, speakers, award winners

R. F. ROMELL, *Vulcan Cincinnati*

Under the gavel of president George Holbrook, the Special Session on Monday morning will hear Neal R. Amundson, head of the Department of Chemical Engineering at the University of Minnesota, who has been chosen to deliver the Tenth Annual Institute Lecture. His subject—*Mathematics for Optimization*. The Institute Lecture will be followed by the annual business meeting with reports on election of officers and directors, etc., and a special briefing on the progress of fund raising for the United Engineering Center.

At lunch on Monday, William E. Vannah, editor of *Control Engineering*, will speak on Process Control Instrumentation in the USSR. Vannah recently returned from a trip to Soviet Russia, and can be expected to provide some provocative insights into Russian technological progress. This talk also forms part of the Student Program.

This year's Professional Progress Award Lecture has been entrusted to W. K. Davis, late of the AEC, now with Bechtel. The time: 11:00 A.M. Tuesday—the subject: *Energy Engineering*. Also on Tuesday, at 12:00 Noon, comes the Unit Operations Luncheon, an interesting innovation which is sure to excite comment—and probably imitation. (For the details, see *CEP*, September, page 100).

Charles A. Thomas, president of Monsanto Chemical Co., will be the guest speaker at the Annual Awards Banquet on Tuesday evening. Presentation of the Professional Progress Award will be made to W. K. Davis, whose lecture on Tuesday morning was mentioned above. Davis joined the staff of the U.S. Atomic Energy Commission in 1954, and in February, 1955, was appointed Director of Reactor Development, a position he held until July, 1958. He is now vice president of the Bechtel Corp.

The 1958 William H. Walker Award will go to Robert L. Pigford, chairman of the Department of Chemical Engineering, University of Delaware, "in recognition of his distinguished contributions to the chemical engineering literature, especially for his publication on the rate processes."

Left—W. Kenneth Davis, winner of the 1958 Professional Progress Award. Right—Robert L. Pigford, who receives the William H. Walker Award.

This year's winners of the Junior Award are: George L. Houghton, Socony Mobil Oil Co.; Arthur B. Metzner, associate professor of chemical engineering, University of Delaware; and Robert D. Vaughn, Shell Development Co. The award is made for their jointly-written paper on *Heat Transfer to Non-Newtonian Fluids* (*A.I.Ch.E. Journal*, 3, #1, p 92).

Student Contest Problem Winners for 1958 are:

A. McLaren White Award—First Prize—Fred I. Stalkup, Jr., Rice Institute (W. W. Akers, counsellor).

Albert E. Marshall Award—Second Prize—Thomas F. Rogers, University of Kansas (J. O. Maloney, counsellor).

Third Prize—Donald E. Jost, University of Delaware (J. A. Gerster, counsellor).

Honorable Mention—D. J. Charlton, Oklahoma State University (J. B. West, counsellor) and Morton Collins, University of Delaware (J. A. Gerster, counsellor).

An event of broad appeal will be the talk on *Observations on Water Pollution* to be given at Wednesday's luncheon by Mark D. Hollis, Assistant Surgeon-General of the U.S. Public Health Service.

Student Day (Monday) opens with a 9:00 A.M. to 12 Noon Symposium

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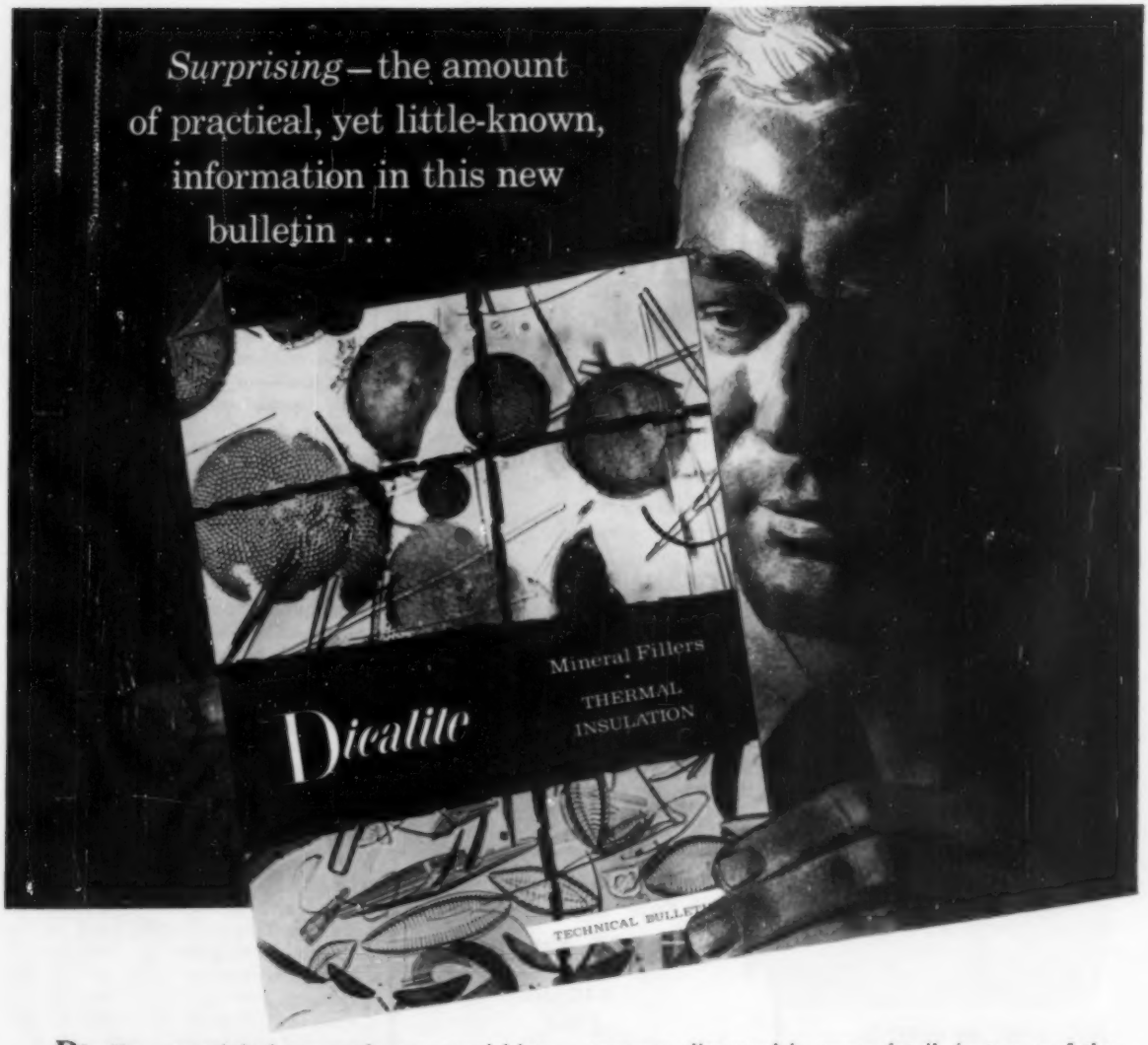
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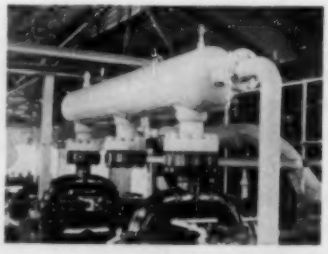

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Cincinnati

from page 116

on *Careers in Chemical Engineering*. Men from the fields of teaching, research and development, process design, production, and technical sales will discuss briefly their respective areas of chemical engineering. Following this formal presentation, the meeting will be thrown open for discussion and the students will have the opportunity to question panel members in more detail. Monday noon, students are invited to attend the luncheon where W. E. Vannah will speak on instrumentation in Russia.

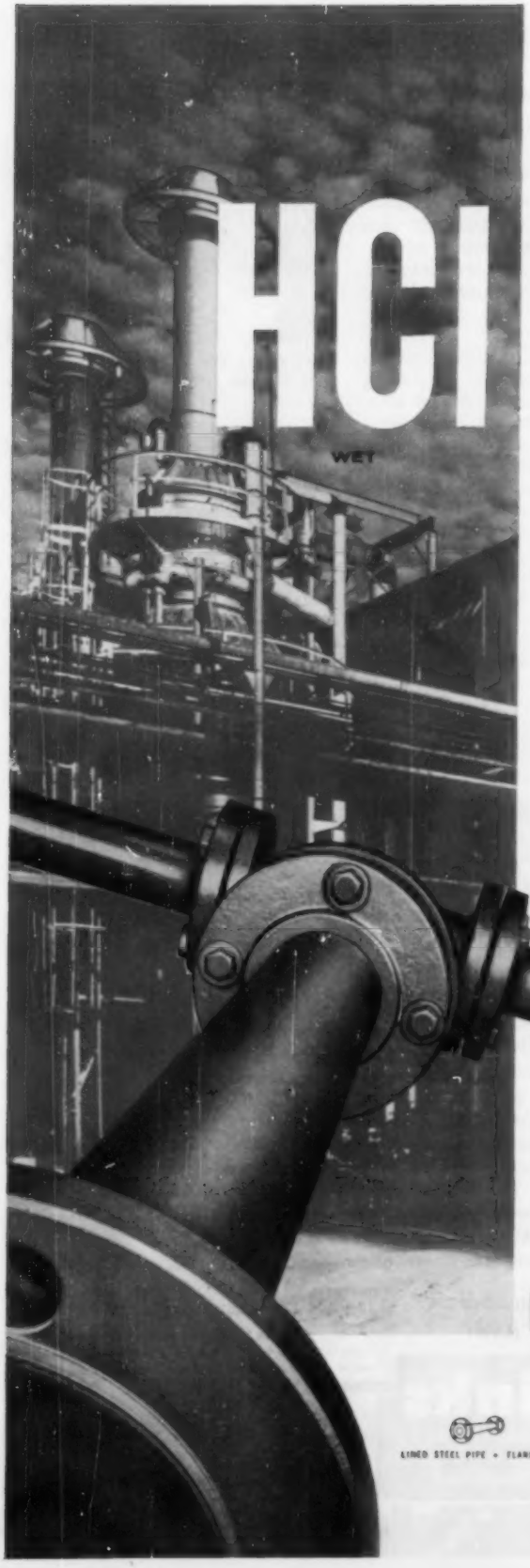
Preprints for Technical Session No. 15, *Nuclear Fuel Processing*, will be sold at the meeting.

Something new

On Saturday, one day before the regular Annual Meeting, A.I.Ch.E. inaugurates its newest service to its membership—a Special Lecture Series intended to provide advanced concepts to members already highly competent in various specialized areas of chemical engineering. Mathematical understanding of the subject matter will be assumed. At Cincinnati, the new series will offer four integrated sessions on *New Ideas in Turbulence*. Principal Lecturer will be Stanley Corrsin, chairman of the Mechanical Engineering Department, Johns Hopkins University. Supporting Lecturers will be Thomas Baron, head of the Chemical Engineering Department, Shell Development Corp., and H. M. Hulbert, director of the Chemical Engineering Department, Stamford Research Laboratories, American Cyanamid Co. The lecture will be limited to 100 preregistrants on a first-come-first-serve basis. A.I.Ch.E. membership is a prerequisite for the lecture series.

Know your authors— better than CEP does

As the result of an extremely unfortunate chain of mechanical circumstances, involving a red-faced *CEP* editorial staff, a red-faced printer, an engraver, sundry messengers, and an imposing supporting cast, twenty-four Cincinnati authors' pictures in our October issue (page 135) somehow came out with the wrong names under them. In detail, the first three pictures in rows 3 and 4, reading from top to bottom, were switched. That is to say, the row reading Ansoff, Morgen, and Gilliland should read Walker, Melcher, and Royer, and vice versa. In like manner, rows 5 and 7 were switched in their entirety. *Sorry!*



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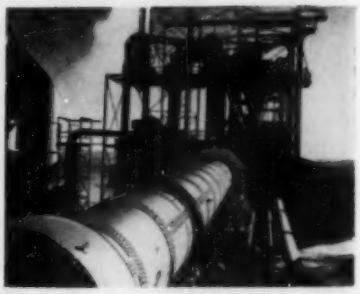
New Nevada plant spurs diatomaceous earth production

Just-started-up Eagle-Picher facilities at Lovelock, Nevada, will produce 36,000 tons annually of natural and calcined products to meet expanding chemical industry demand.



Giant rotary kiln at Eagle-Picher, Lovelock, Nevada. In background, process cyclones.

Increasing needs in the ammonium nitrate, calcium silicate insulation, paper, and filter aid industries were behind Eagle-Picher's decision to proceed immediately with the exploitation of what is said to be one of the largest and highest quality deposits of diatomaceous earth to be uncovered in recent years, at Lovelock, Nevada.

Following an industry-wide marketing survey based on testing of actual products turned out in a pilot plant installation, the new full-scale plant, started up in September, has a capacity of 36,000 tons per year, provision for early expansion.

Several grades of natural and calcined products will be made. One grade will be used as an industrial all-purpose oil and grease absorbent, another as lightweight aggregate for insulating concrete, and as catalyst supports. As a filter aid, applications are expected in sugar refining, wine-making, brewing, paint and varnish manufacture, water purification, and in production of pharmaceuticals such as aureomycin, penicillin, and streptomycin.

Heart of the plant is a 9 ft. diameter by 120 ft. long rotary kiln, said to be one of the largest in the industry (shown).

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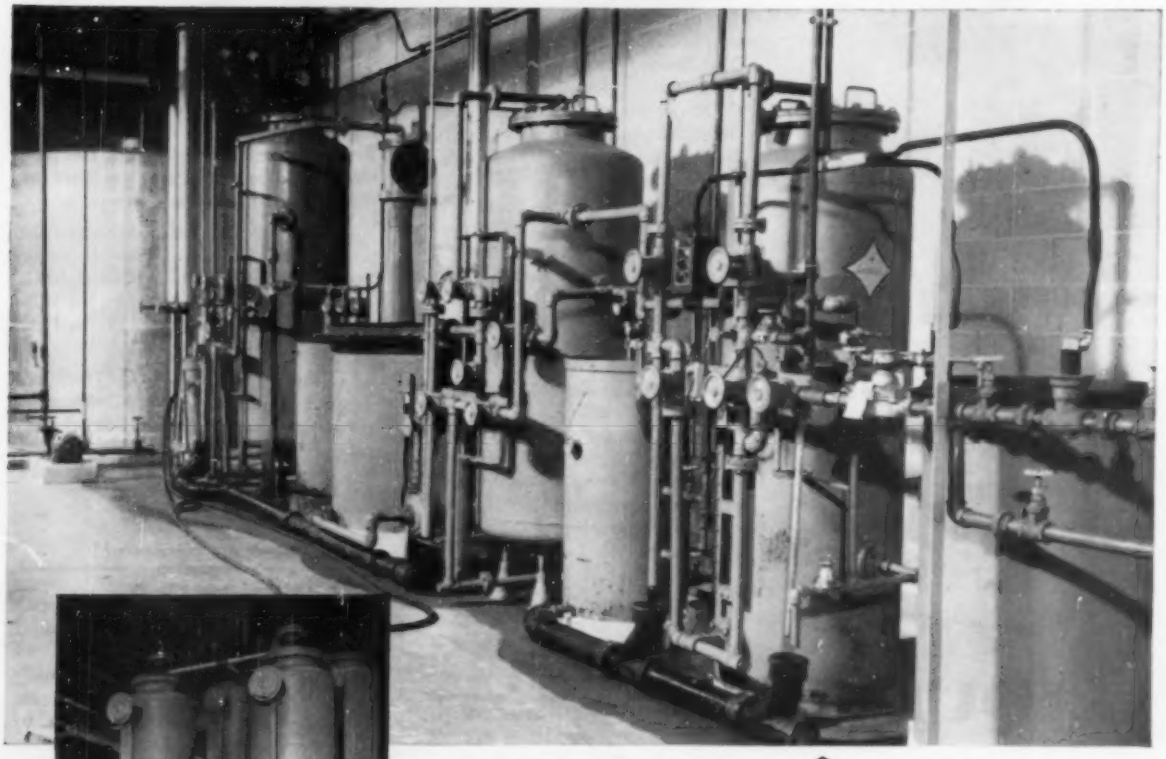
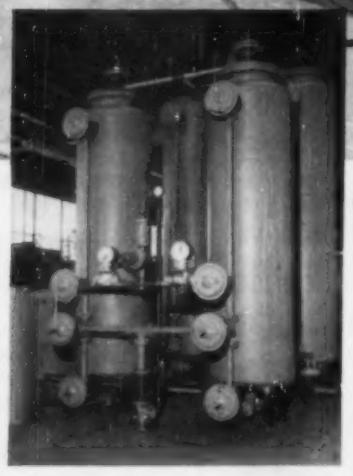
INDUSTRIAL ION EXCHANGE TECHNIQUES

. . . low cost solution to specialized purification problems





EXAMPLE 1: *Purification of Formaldehyde.* Specialized anion exchange technique removes formic acid from formaldehyde. This *Industrial* semi-automatic, dual unit also "up-grades" water white formaldehyde for resin manufacture—yields final resins with resistance to off-color blush or bloom.

EXAMPLE 2: *Chemical preparation.* An *Industrial* mixed-bed ion exchange unit used for removal of sodium formate and formic acid from an organic polyhydric alcohol intermediate. Process facilitates subsequent purification by evaporation.

• Are you concerned with the removal of mineral impurities from solvent solutions—chemical intermediates—purification of glycerine—or other materials which usually require tedious, costly processing by alternate methods? If you are faced with the problem of purifying such materials, and if they contain even traces of moisture, then *Industrial*-engineered ion exchange techniques and equipment may provide a complete and inexpensive answer to your problem.

The two installations of *Industrial* ion exchange equipment illustrated here are typical of the many specialized applications of ion exchange developed and engineered by *Industrial* to meet specific chemical process industry requirements.

To evaluate the possibilities of these techniques to solve your purification problems, and to obtain an analytical study, consult *Industrial*, soon.

For general information covering *Industrial* Ion Exchange equipment, write for a copy of BULLETIN 200.

INDUSTRIAL

C-158

INDUSTRIAL FILTER & PUMP MFG. CO.
5910 Ogden Avenue, Chicago 50, Illinois

PRESSURE FILTERS ◆ ION & HEAT EXCHANGERS ◆ WASTE-TREATING EQUIPMENT

DO YOU HAVE A LIQUID DRYING PROBLEM?

You can now attain water levels below 10 ppm and sometimes below 1 ppm by using Molecular Sieve driers. This degree of dryness would be difficult or impossible with paper presses, distillation towers or chemical desiccants.

Molecular Sieve drying systems are available in any size with either single or multiple beds. Operation can be continuous or intermittant and variation of flow rates or composition of the stream does not affect product purity. Even at low inlet water levels, Molecular Sieve systems maintain a high water capacity. *And,* important in so many areas, Molecular Sieves have high water capacity even at elevated temperatures.

Many plants are now taking advantage of this highly efficient method of drying liquid systems. Here are some examples of liquids which are now being dried commercially with LINDE Molecular Sieves—

Acrylonitrile	n-Hexane
Benzene	Phenol
Butane	Propylene Dichloride
Ethylene Dichloride	Propylene
Flourocarbon Refrigerants	Pyridine
Hydrocarbon	Solvent
Mixed Xylenes	Solvent Mixture
n-Heptane	Transformer Oil

Molecular Sieves have also been tested in many others systems—systems as difficult to dry as water-alcohol azeotropes, ketones, ethers, and so on. Performance data are available on request.

If you are looking for a way to dry a liquid stream—or if you need to improve the performance of an existing drying system—let us show you how Molecular Sieves can work for you. When you order your Molecular Sieve Drier, we will work closely with the equipment manufacturer of your choice. Write, wire or phone today, Molecular Sieves Dept., Linde Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. Telephone YU 6-6200, Ext. 365.

Linde TRADE MARK MOLECULAR SIEVES

UNION CARBIDE

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people in management & technology

from page 114

Blaw-Knox, Chemical Plants Division, announces the appointment of **George F. Kline** as manager of its Petroleum and Petrochemicals Department. Kline joined Blaw-Knox in 1954, and for the past year has been assistant manager of the department he now heads.

New project chemical engineers at the Whiting Research Laboratories of Standard Oil (Indiana) are **Ralph G. Zelmer, William M. Herring, Jr., William C. Taylor, Jr.,** and **Richard A. Ahlbeck.**

At Continental Oil Co., Houston, Texas, **James G. Hough,** assistant general manager of the Petrochemicals Department, has been promoted to manager of the department's Chemicals Division.

people in marketing

George A. Green has been named by Beckman Instruments, Inc., as Eastern regional manager for all process instrument sales. Prior to joining Beckman, Green was a senior development engineer with Great Lakes Carbon Corp.

Westvaco Chlor-Alkali Division, Food Machinery and Chemical Corp., has appointed **John R. Jacobucci** as alkali product manager. Prior to his present assignment, Jacobucci was general superintendent of the company's soda ash mining and production facilities at Green River, Wyoming.

Harry B. Warner (left) has been named vice-president, marketing, of B. F. Goodrich Chemical Co. He succeeds **James C. Richards,** recently made vice-president, sales, of B. F. Goodrich Industrial Products Co. Warner is a member and past president and director of the Cleveland Section, A.I.Ch.E.

Blaw-Knox, Buflovak Equipment Division, announces appointment of **Robert B. Scrimgeour** as special sales representative for the company's Roto-Vak agitated film contactor. Before joining Buflovak, Scrimgeour was associated with Pfaudler Co., Dorr-Oliver, and Columbian Carbon.

continued on page 124

They're called SERVICE ENGINEERS at Durco. When you have a tough pumping problem that is really giving you trouble, a Durco SERVICE ENGINEER is near-by.

Make your own job easier. Get the right pump in the right alloy to do the job as it should be done. Durco service engineers can help you put in the pump that will give you continuous service, with minimum maintenance, at lowest operating costs.

Durcopumps are available with heads to 345′ and capacities from ½ to 3000 gpm in fourteen standard corrosion resisting alloys.

Durco service engineers are available almost everywhere.

DURCO
CORROSION RESISTING ALLOYS & EQUIPMENT

THE DURIRON COMPANY, INC.
DAYTON, OHIO

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ILLCO-WAY
ionXchange

soften
de-alkalize
clarify
WATER

REMOVE
organic matter
turbidity
color
iron

U. S. AIR FORCE PHOTO

HIGH-FLOW, UP-FLOW
CLARIFIER

The Clarifier shown above is part of an ILLCO-WAY ionXchange installation, at a metal-finishing plant, which is used for waste disposal and water recovery. Similar Clarifiers are widely employed to clear up surface waters used by various industries — removing organic matter, hardness, alkalinity, turbidity, color, and iron, as required by specific conditions.

USED AS PRE-TREATMENT

In many instances it is more economical to use a Clarifier in the initial part of a system. Certain water supplies contain organic matter or turbidity which can be removed most efficiently by flocculation, or contain carbonate hardness or alkalinity which can be largely reduced by precipitation — in which situations, a Clarifier is indicated as best. *Let us analyze the water you propose to use, and advise you.*

ILLCO-WAY
ILLINOIS WATER TREATMENT CO.
840 Cedar St.
Rockford, Ill.

NEW YORK OFFICE: 141 E. 44th St., New York 17, N.Y.
CANADIAN DIST.: Pumps & Softeners, Ltd., London, Can.

people in marketing

from page 122

Industrial Rayon Corp. announces appointment of **B. J. Benson** to market development manager of its Industrial Products Division. Benson, who came to Industrial Rayon in 1949, was formerly supervisor of the company's tire cord evaluation laboratory.

Joseph Meisler has been appointed technical commercial manager of the Cryogenics Department, Philips Electronics, Mount Vernon, N.Y. Meisler was previously head of the process development department at Paul Hardeman, Inc.

Charles E. Beaver, formerly vice-president, sales, and a director of Research-Cotrell, joins Buell Engineering in a sales and marketing capacity.

American Smelting and Refining has appointed **John S. Smart, Jr.** as general sales manager. Smart joined Asarco in 1936, as a metallurgist in the company's Central Research Laboratories.

George W. Heller, formerly with Thermax Wire Corp., New York City, has joined Tensolite Insulated Wire Co., Tarrytown, N.Y. as vice-president for technical service and sales. Heller's experience includes five years with Du Pont, in research, development, and sales.

Necrology

William E. Yates, 48, resident manager of the Lawrence, Kansas, plant of Westvaco Mineral Products Div., Food Machinery and Chemical Corp.

Correction

In September CEP, People, page 157, it was reported in error that **Max S. Peters** had been appointed head of the Division of Chemical Engineering in the Department of Chemistry and Chemical Engineering at the University of Chicago. Peters is at the University of Illinois, *not* the University of Chicago.

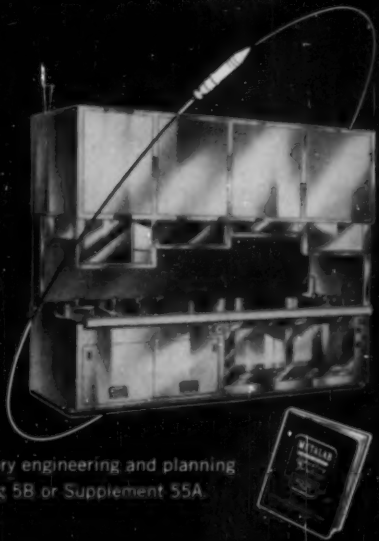
METALAB

PROGRESS IS MADE IN METALAB EQUIPPED LABORATORIES

History shows that a lack of laboratory facilities has hindered scientific progress.

While scientific theories are essential, there is no substitute for actual laboratory research and experimentation.

Metalab manufactures a complete line of METAL or WOOD laboratory equipment including: chemical fume hoods, and fume hoods for radioactive materials, storage cabinets and cases, center and wall tables, sinks, and specialized units for any requirements you may have for your laboratory.



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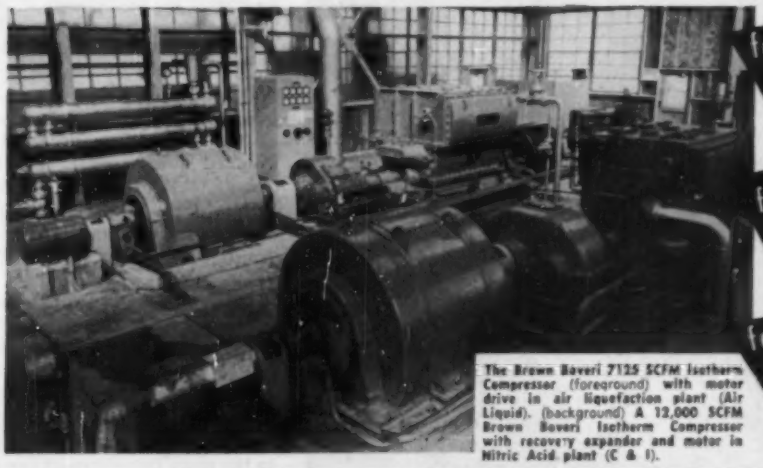
METALAB Equipment Company
DIVISION OF NORBUTE CORPORATION

246 Duffy Avenue, Hicksville, L. I., New York

If you need LARGE VOLUME* MEDIUM PRESSURE* Oil-Free Air—



The Brown Boveri 7125 SCFM Isotherm Compressor (foreground) with motor drive in air liquefaction plant (Air Liquid). (background) A 12,000 SCFM Brown Boveri Isotherm Compressor with recovery expander and motor in Nitric Acid plant (C & I).

for SUPERCHARGING of a CHEMICAL PROCESS

for OXYGEN PRODUCTION

for OTHER CHEMICAL PROCESSES

you need a BROWN BOVERI ISOTHERM COMPRESSOR

WHERE large volumes of oil-free air (5,000 SCFM and up, 100-300 PSIA)* are required, there is no better equipment available today to achieve "close to isotherm" type of compression, assuring the lowest possible kW input, than a Brown Boveri Isotherm Compressor.

If "tail" gas is available, the high efficiency, reaction type Brown Boveri expander can be applied in the cycle with the Isotherm Compressor to improve further the economy of the process. As drive for the compressor a synchronous, induction or other type of motor, or a steam- or gas-turbine can be used.

Over half a century's background in the manufacture of this Brown Boveri equipment (including control and all accessories) is your positive assurance of the ultimate in the reliability of this "packaged" unit. Write for more information, *today!*

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Atlanta, Ga. • Birmingham, Ala. • Boston, Mass. • Buffalo, N. Y. • Chicago, Ill. • Cleveland, O. • Dallas, Tex. • Denver, Colo. • Detroit, Mich. Hamilton, O. • Jacksonville, Fla. • Kansas City, Mo. • Knoxville, Tenn. • Miami, Fla. • Minneapolis, Minn. • New Orleans, La. • New York, N. Y. Pasadena, Cal. • Pittsburgh, Pa. • Portland, Ore. • Roanoke, Va. • San Francisco, Cal. • San Juan, P. R. • Syracuse, N. Y. • Tucson, Ariz.

Industrial Scale Hydrogen-Deuterium Distillation-Separation in France

In recent years, the range of industrial gas separation by low temperature methods has been progressively increased to include the recovery and purification of almost all known gases. Although liquefied gases whose boiling points lie at the lower extremity of this range, such as hydrogen and helium, have been produced and studied for some time, it is only within the last few years that the treatment of such gases has been carried out on an industrial scale.

Plants for the purification of hydrogen are quite common today and the L'Air Liquide company of France has done much of the pioneering work. A good example of L'Air Liquide's participation in the development of new processes is the production of heavy water by the distillation of hydrogen.

The French Atomic Energy Commission requested L'Air Liquide to study the problems involved in the separation of deuterium from liquefied hydrogen by distillation. The temperature range involved is approximately 6°F., but at this low temperature level (—417° to —423°F.) the difference is sufficient to allow a practical separation to take place.

As an abundant source of hydrogen it was decided to use the ammonia synthesis gas produced at the Toulouse plant of the Office National Industriel de l'Azote, or O.N.I.A., which is one of the largest ammonia producing plants in the world (close to 550 tons per day by 1959). Taking into account the low conversion ratio of hydrogen to deuterium, it was estimated that production could reach 40 tons of heavy water a year.

The preliminary studies were made with electrolytically-produced hydrogen, as it required only minor purification. L'Air Liquide in 1954 constructed an industrial scale pilot plant, operating it to treat 1769 SCFM of electrolytic hydrogen feed stock (equivalent to 1000 gallons of liquid hydrogen per hour) for approximately one year.

Apart from the usual problems of producing and maintaining the low temperatures necessary for the operation of this plant, Air Liquide engineers were faced with other difficulties. Problems of purification and insulation were different from those in the more conventional low temperature plants.

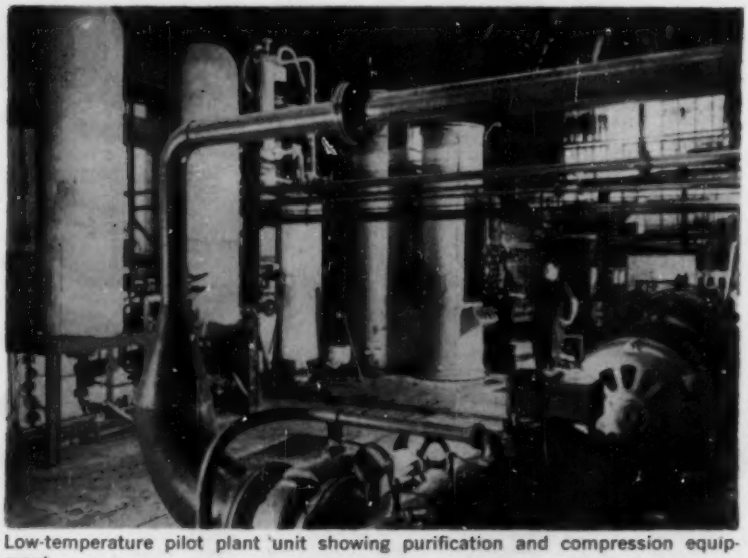
As the impurities of synthesis hydrogen, i.e., carbon monoxide and nitrogen, would be solidified in the plant at operating temperatures, use was made of this fact in the design and development of apparatus for the removal of these impurities.

A small pilot plant was erected in 1955 to study the difficult purification problem, using ammonia synthesis gas as a feed. This was a steel and copper pilot unit and handled up to 120 cfm of hydrogen containing up to 2% of nitrogen. The reduction of nitrogen to 2% was accomplished simply by fractional liquefaction.

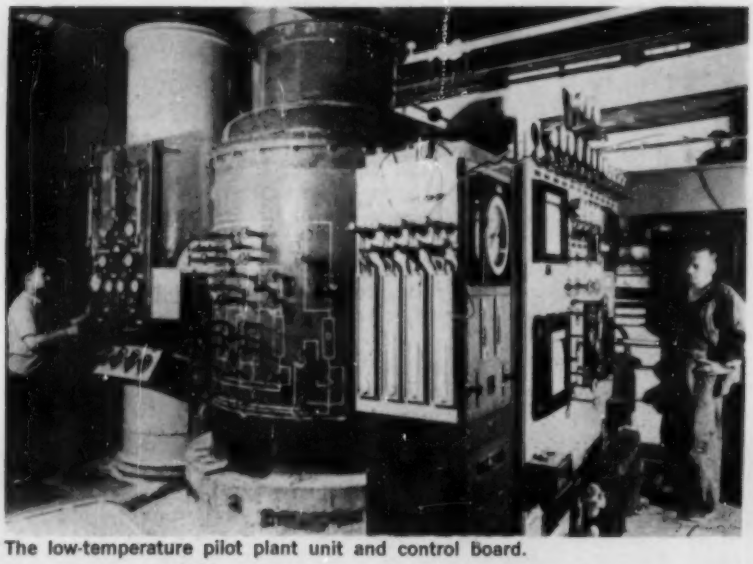
This small pilot plant is said to have been successfully operated with ammonia synthesis gas under normal industrial conditions for continuous runs of several weeks.

The operating range of temperatures in the hydrogen plant lies below the temperature at which atmospheric air condenses and so special insulation precautions have to be taken to pre-

continued on page 128



Low-temperature pilot plant unit showing purification and compression equipment.



The low-temperature pilot plant unit and control board.

BETHLEHEM AGITATED PAN DRYERS give you better heat transfer and so LOWER your OPERATING COSTS

Bethlehem selects the method of agitation that most efficiently renews drying surfaces. In this way Bethlehem increases heat transfer coefficients and so economizes on Costs.

The drawings illustrate two successful agitation methods from Bethlehem's Case Histories.

In cases where the material is on the plastic side our knives (as shown in figure A) provide increased shear, allowing for more effective surface renewal.

Many granular materials tend to form deposits on the dryer walls. If deposits are allowed to form they lower heat transfer coefficients. Figure B shows an agitation system designed to prevent this formation.

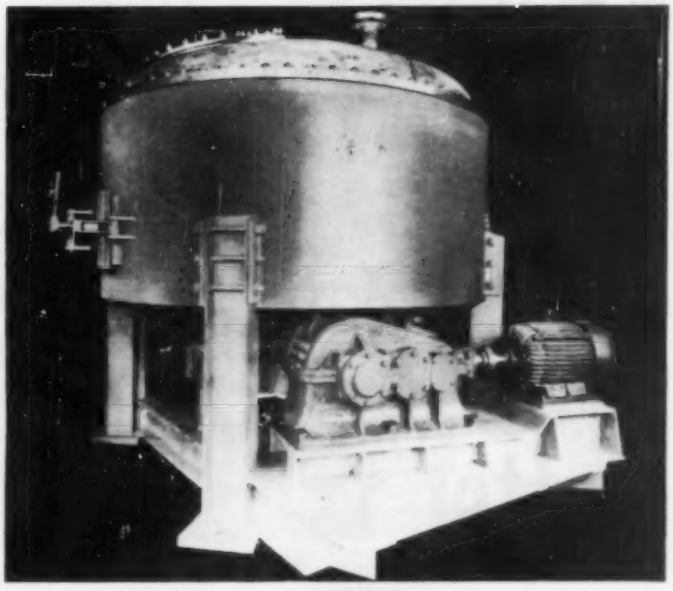


FIG. A

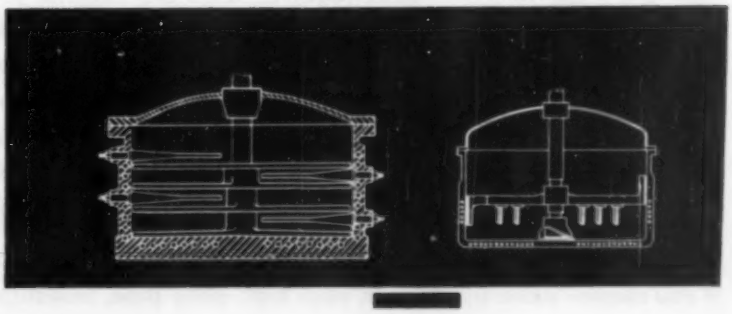


FIG. B

Completing the coupon below will bring you Folder 351 giving typical drying coefficients and power requirements.

BETHLEHEM FOUNDRY & MACHINE COMPANY

BETHLEHEM PENNSYLVANIA

write for a copy of Technical Bulletin 351 with full information

BETHLEHEM FOUNDRY & MACHINE COMPANY
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Gentlemen:
Please send me a copy of your Technical Bulletin No. 351

Name _____
Firm _____ Position _____
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DURASPUN

Centrifugally Cast Pipe

High Alloy

is Better Pipe

Centrifugal castings are superior castings. The metal is sounder, finer-grained, more uniform. It is free of gas pockets, blow holes and other defects often difficult to keep out of static castings. Tensile strength is close to that of rolled or hot-forged alloy steel. Dimensions are accurate, usually requiring less machining and finishing and thus speeding production.

If you require *extra* qualities in your high alloy pipe, investigate DURASPUN Centrifugally Cast Pipe. We can produce it in OD ranging from 2½" to 24" and in lengths up to 15' according to diameter. Our experience in the field of centrifugal high alloy castings dates back to 1931. Our experience in the field of static high alloy casting goes back to 1922. We can give you good service.

The DURALOY Company

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EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
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DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

Hydrogen-deuterium

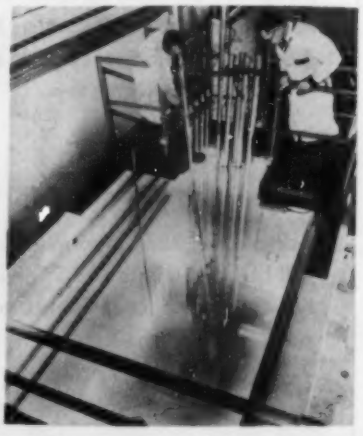
from page 126

vent the formation of liquid air on the outside of the vessels and piping, which together with its subsequent evaporation and rectification to produce oxygen, would constitute a serious explosion hazard in the presence of possible hydrogen leaks.

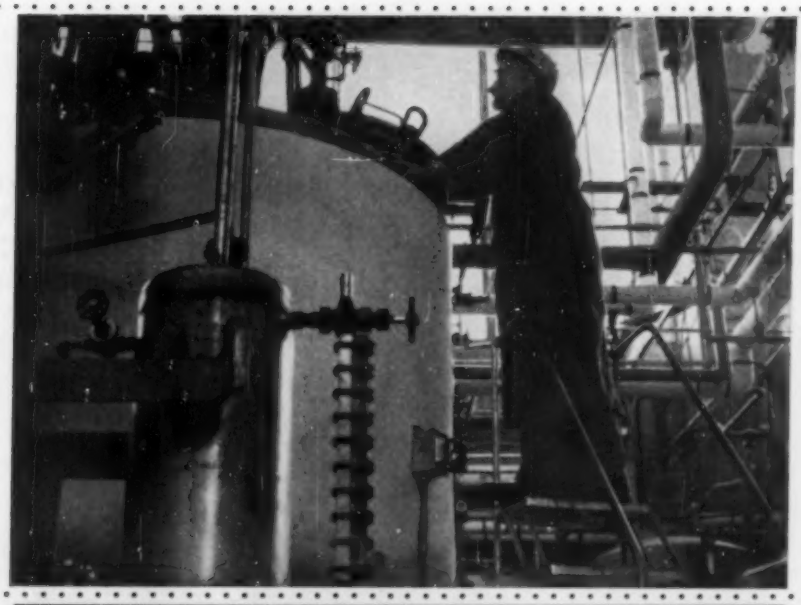
Other problems of heat exchange, analysis and operation are said to have been successfully overcome and it is now believed by L'Air Liquide to be feasible to design and erect a plant to produce the design quantity of 40 tons/yr. of heavy water from the O.N.I.A. ammonia plant.

In addition, an industrial scale experimental plant was constructed at Toulouse and is being operated not only to produce heavy water, but to explore the entire field of cryogenics, purification, and distillation at the temperature range of liquid hydrogen.

Industrial scale data have been collected on heat exchange, distillation trays, materials of construction, expansion machines, control valves, instrumentation, insulation materials, ortho-para catalysis, and purification devices.



A "hot exponential" facility has gone into operation at the Critical Experiment Laboratory of Babcock & Wilcox at Lynchburg, Va. Goal of research with the new unit is accurate prediction of the behavior of reactor cores at operating temperatures. Neutron flux measurements at high temperatures and pressures are now possible without lowering the temperature or removing test material. This is made possible, says B&W, by the first nuclear installation of the Teleflox wire activation system. Dysprosium-aluminum wires, encased in titanium flexible cables are led into the facility. Following a predetermined exposure, the wires are withdrawn and the gamma radiation measured with a scintillation detector.



CONDENSATIONS – ALKYLATIONS IN STANDARD EQUIPMENT WITH MHI SODIUM HYDRIDE OIL DISPERSION

higher yields, faster, at lower temperatures

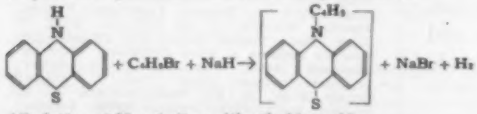
Higher yields, faster, at lower temperatures . . . safe reactions without forcing, without by-product alcohols . . . that's what you'll find MHI sodium hydride oil dispersion will provide! MHI NaH is a powerful, easy-to-handle condensing agent for Claisen, Dieckmann, Stobbe, nitrile and related ester condensations, alkylations and other base catalyzed reactions. In addition to other advantages over such common reagents as sodamide, sodium methylate and sodium metal, MHI NaH eliminates forcing techniques. Condensations are carried out without forcing and without the formation of by-product alcohol common with sodium methylate reactions. Equally important is the use of NaH in oil for metallation and alkylation of amines using the NaH in conjunction with alkyl halides to form unsymmetrical amines.

MHI NaH crystals are uniformly dispersed in Bayol 85 — an inert white mineral oil. With this oil film, MHI NaH crystals will not react with the moisture in the air.

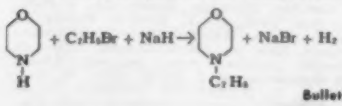
It can be mechanically or hand-fed directly to the reaction vessels. Because the Bayol is readily miscible in organic solvents, the microfine, highly reactive hydride reacts easily, smoothly and rapidly. This cuts reaction times and markedly improves yields at lower operating temperatures.

HERE ARE SEVERAL ALKYLATION EQUATIONS OF SIGNIFICANT INTEREST:

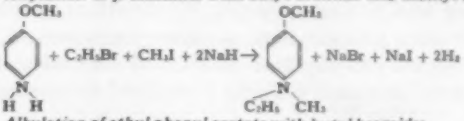
Alkylation of phenothiazine with n-butyl bromide:



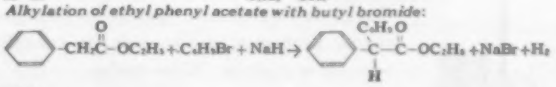
Alkylation of Morpholine with ethyl bromide:



Alkylation of p-anisidine with ethyl bromide and methyl iodide:



Alkylation of ethyl phenyl acetate with butyl bromide:



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Metal Hydrides Incorporated

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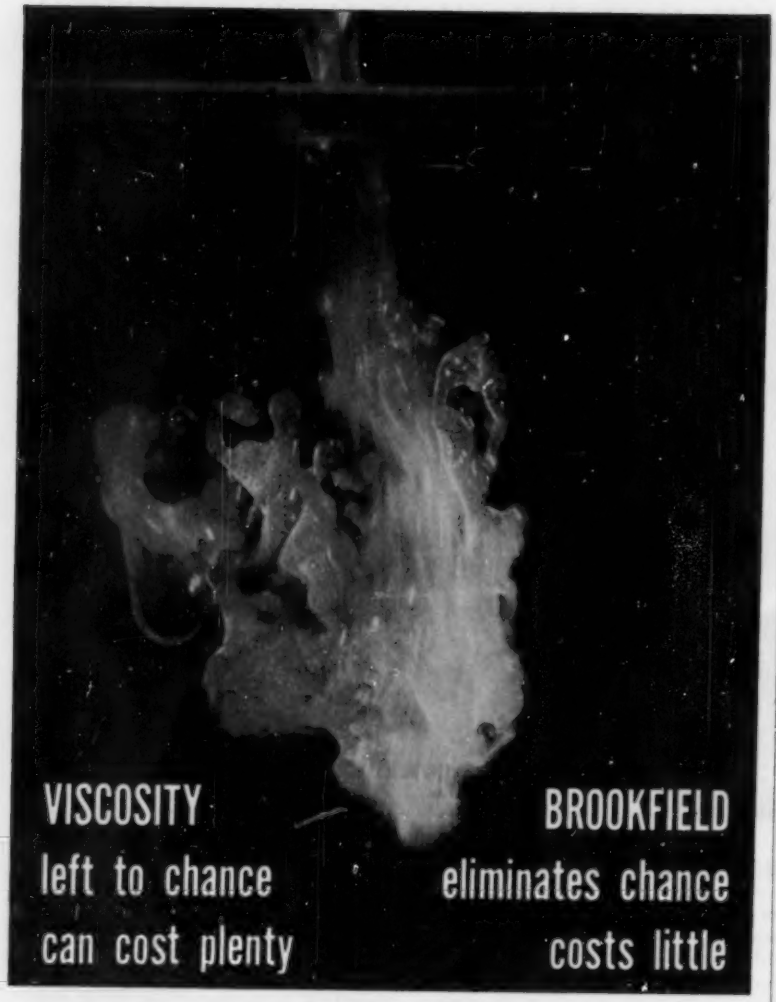

If you, like most chemical processors, are in the rough marketing position whereby you can't tolerate needless production waste . . . then give this some thought.

Have you considered the role of viscosity control in your processes? If not — you should! Viscosity is a product dimension that experience has shown should not be ignored . . . a product dimension Brookfield has proved need not be ignored. Both Brookfield laboratory Synchro-Lectric Viscometers and process-mounted Viscometrans involve small investments: yet they provide easy, accurate measurement, evaluation and control of viscosity in any fluid. Brookfield instrumentation is so simple that no special personnel training is required for operation.

Complete information, specific to your particular problems, if you wish, is available without obligation. Write today.

THE WORLD'S STANDARD FOR VISCOSITY MEASUREMENT AND CONTROL

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future meetings

1958—A.I.Ch.E.

● **Cincinnati, Ohio.** December 7-10, 1958. **Netherland Plaza Hotel. A.I.Ch.E. Annual Meeting.** For details, see page 116.

1958—Non-A.I.Ch.E.

● **Karaikudi, India.** Week of Dec. 21, 1958. **Central Electrochemical Research Institute.** Symposium on **Electrolytic Cells.** Technical Chmn.: H. V. K. Udupa, Alagappa College P.O., Karaikudi, S. Rly, India.

● **Washington, D.C.** December 29-30, 1958. Hotel Statler. **American Association for the Advancement of Science.** Symposia on **National and International Aspects of Systems of Units;** to include: **National and International Status of Systems, Comparison of Different Industrial Systems, and Methods for Unification and Simplification.** Info. available from Secretary, Section M (Engineering) c/o Engineers Joint Council, 29 West 39 Street, New York 18, N.Y.

1959—MEETINGS—A.I.Ch.E.

● **Atlantic City, N. J.** March 15-18, 1959. **A.I.Ch.E. National Meeting.** Chalfonte Haddon Hall Hotel. Gen Chmn.: J. D. Stett, Dept. Mech. Eng., Rutgers Univ., New Brunswick, N. J. Tech. Prog. Chmn.: N. Morash, Natl. Lead Co., P.O. Box 58, So. Amboy, N. J. **Recent Advances in Plastic Materials of Construction**—M. P. Gigliotti, Monsanto Chem. Co., Plastics Div., Springfield, Mass. **Business & Technology**—J. Happel, NYU. **Theoretical and Laboratory Work on Liquid-Liquid Extraction**—R. E. Treybal, NYU, Univ. Heights 53, N. Y. **Laboratory and Pilot Plant Techniques**—G. W. Blum, Goodyear Tire & Rubber Co., Akron, Ohio. **Missiles, Rockets & Satellites**—G. C. Szego, Gen. Elect., Aircraft & Gas Turbine Div., Cinn. 15, Ohio. **General Papers** (2 sessions). J. Joffe, Newark Coll. of Eng., 367 High St., Newark 2, N. J. and E. C. Johnson, Dept. of Chem. Eng., Princeton U., Princeton, N. J. **Computer Control of Processing Units**—J. M. Mozley, Johns Hopkins Hospital, Baltimore 5, Md. **Startup of New Chemical Plants**—M. L. Nadler, DuPont, Penns Grove, N. J. **Care and Feeding of Executives**—J. S. Wilson, Heidrick & Struggles, 20 No. Wacker Dr., Chicago 16, Ill. **Mechanics of Fluid-Particle Systems**—S. K. Friedlander, Johns Hopkins Univ., Balt., Md. **Process Data & Design Methods for Nuclear Fuel Recovery**—C. E. Stevenson, Rsch. Dir., P.O. Box 1259, Idaho Falls, Idaho. **Thermodynamics of Phase Equilibria**—E. M. Amick, Jr., Chem. Eng. Dept., Columbia U., New York 27, N. Y. **Market Research & the Chemical Engineer**—William Copulsky and R. Cziner, Grace R&D Co., Hanover Sq., New York 4, N. Y. **Thermal Stability of Jet and Rocket Fuels**—C. J. Marsel, NYU, Univ. Heights, New York, N. Y. **Wood as a Chemical Raw Material**—E. G. Locke, U. S. Forest Prod. Lab., Madison, Wis.

Deadline for papers: November 16, 1958.

● **Cleveland, O.** April 5-10, 1959. **Nuclear Congress. Co-sponsored by A.I.Ch.E. and others.** A.I.Ch.E. representative: E. B. Gunyou, Alco Prods., Inc., Schenectady 5, N. Y.

● **Kansas City, Missouri.** May 17-20, 1959. Hotel Muehlebach. **A.I.Ch.E. National Meeting.** Gen. Chmn.: P. C. Fowler, Consulting Chem. Engr., 7515 Troost Ave., Kansas City, Mo. Tech. Prog. Chmn.: Fred Kurata, Chem. Eng. Dept., Univ. of Kansas, Lawrence, Kansas. **Reaction Kinetics**—M. M. Gilkeson, Dept. of Chem. Eng., Tulane Univ., New Orleans, La. **How to Become a More Proficient Technical Engineer. Heavy Chemicals**—N. J. Ehlers, Columbia-Southern Chem. Corp., 1 Gateway Center, Pitts. 22, Pa. **Petrochemicals**—G. E. Montes, Nat'l. Petrochemical Corp., Tuscola, Ill. **International Licensing and Collaboration**—R. Landau, Scientific Design Co., 2 Park Ave., New York, N. Y. **General Papers** (2 sessions). J. O. Maloney, Univ. of Kansas, Lawrence, Kan. and Merk Hobson, Univ. of Nebraska, Lincoln, Nebr. **Non-Equilibrium Fluid Mechanics**—M. J. Rzasa, Cities Services Res. Lab., P. O. Box 402, Cranbury, N. J. **Role of Wetting and Capillarity in Fluid Displacement Processes**—C. S. Kuhn, Magnolia Petroleum Co., 907 Thomasson Dr., Dallas, Tex. **Thermodynamics of Jet & Rocket Propulsion**—G. C. Szego, Gen. Elect. Aircraft & Gas Turbine Div., Cinn. 15, Ohio. **Computers and Pipelines**—R. L. McIntire, The Datics Corp., 600 Camp Bowie Blvd., Fort Worth, Texas. **What's New in Liquid Metals Technology**—H. M. Rodekohr, Ethyl Corp., P. O. Box 341, Baton Rouge, La. **Ten Ways to**

continued on page 137

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7. Flare & flatten test
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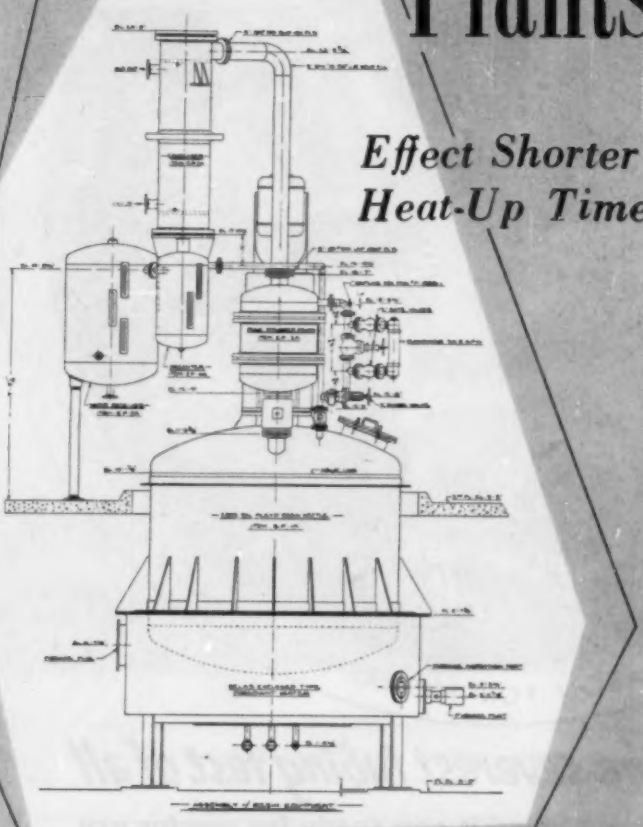

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Objections to the election of any of these candidates from Members and Associate Members will receive careful consideration if received before December 15, 1958, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

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continued on page 138

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Impact type pulverizing mills making inroads in chemical processing field

Impact-type mills may be the answer to your pulverizing problem. Here is an assessment of their advantages and their drawbacks, with case-history data.

True impact mills differ in one essential respect from any of the other types of particle size reduction units available commercially to the chemical engineer—attrition mills, hammer mills, ball and pebble mills, etc. In the true impact mill, clearances within the mill are such that material being reduced in size cannot bridge the gap between the accelerating rotor and the decelerating target against which the material is thrown. The machine is designed to accelerate the material to the required velocity, and to eject it from the rotor through a gap of sufficient width so that the largest particle is completely media-suspended when it strikes the target area. (Whether the target area be stationary or contra-rotating is immaterial.) Therefore, the particle has only its inherent kinetic energy as the grinding force. It has been demonstrated that the capacity of a true impact mill varies almost exactly as the inverse square of the peripheral velocity. Were there excessive frictional or attritive forces, this exact relationship would not exist.

Data given here were kindly furnished by the Entoleter Division, Safety Industries, Inc., of New Haven, Conn., and are based on performance of the Entoleter Impact Mill (Figure 1). However, the data should be comparable to those obtained with any type of true impact mill.

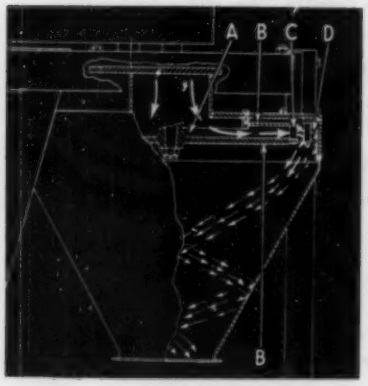


Figure 1. Product stream enters through inlet onto surface of spinning rotor (A) and slides out between top and bottom plates (B) in thin even stream. Impactors (C) at edge of rotor shatter material and accelerate it to high velocity. Particles then shatter themselves against stationary impactors in target area (D).

Major advantages of the impact mill are said to be:

- Extremely good control of product size. Tables 1 and 2 gives some actual test results obtained by Entoleter machines on samples of such different products as PVC resin powders and sodium hexametaphosphate.
- Minimum heat rise. In grinding operations, practically all horsepower applied to the operation ultimately shows up as heat in the product. The elimination of frictional and attritive forces in an impact mill substantially reduces the product heat build-up. For a machine operating with air excluded, the normal heat rise can, according to Entoleter engineers, be calculated with very good accuracy by the following equation:

(HP × 2570/lb. product per hr. × specific heat) × 0.9

Table 1. PVC resin powders from dryer at approximately 130°C at inlet of mill.

PROPOSED GRINDING RATE: 1,500 lb./hr.

PURPOSE OF TEST: To produce maximum amount of minus 20 mesh with minimum amount of minus 100 mesh.

RESULTS

U.S. MESH	As Rec'd. %	CONTROL %	A %	B %	C %	D %
8	2.9	...	0.0	1.0	0.6	0.5
20	85.8	...	5.5	34.0	41.9	52.6
40	10.4	...	27.5	29.0	29.6	28.2
100	0.9	...	48.5	29.0	23.2	15.6
Pan	trace	...	18.5	7.0	4.6	3.1
	100.0%		100.0%	100.0%	99.9%	100.0%
Mill used			Series 27	same	same	same
Rotor			0-36	same	same	same
RPM			3,500	3,000	2,500	same
Horsepower			20 Vari	same	same	same
Feed Rate, lb./hr.			1,500	same	same	same
Temperature			80°F	110°C	110°C	110°C

Table 2. Sodium Hexametaphosphate, pre-crushed by hammer mill.

PROPOSED GRINDING RATE: 15,000 lb./hr.

PURPOSE OF TEST: Reduce particle size to 75% minus 100 mesh with 0% plus 20 mesh.

RESULTS

U.S. MESH	As Rec'd. %	CONTROL %	A %	B %	C %
8	62.0	0.0	0.0	0.0	0.0
20	28.0	0.0	trace	trace	0.0
60	3.8	...	10.9	6.1	trace
100	.38	...	14.9	9.2	0.87
Pan	5.7	75.0 min.	74.2	84.5	99.0
	99.88%		100.0%	99.8%	99.87%
Mill used			Series 27	same	same
No. of passes			1	1	2
Rotor			0-36	same	same
RPM			3,500	3,850	3,850
Horsepower			20 Vari	same	same
Feed Rate, lb./hr.			15,000	same	same

This temperature rise can be further inhibited by passing air through the mill, which can be done without affecting the grind in any way.

• Wide range of impact velocities through choice of rotor diameters and speeds (Figure 2). In addition to the velocity range shown in Figure 2, a new design, featuring counter-rotating rotors, permits impact velocities up to 70,000 ft./min.

Abrasion was stumbling block

Chief stumbling block to the application of impact mills to many chemical processing uses has been the question of wear on rotating parts. This wear is critical, since velocities of the rotors, and consequently, stresses within the rotor plates, are high. The rotating member may thus be weakened to the point of failure if wear is allowed to progress. The application of carbide coatings, while adding wear resistance, also adds considerable weight to the rotor, thereby increasing still further the strength requirements for the original rotor plate. However, new techniques in the application of carbide coatings, and the use of roll forgings, have aided in maintaining both strength and wear resistance even at high velocities. In addition, since maximum wear occurs immediately in front of the impactors, this area can be protected by replaceable wear plates.

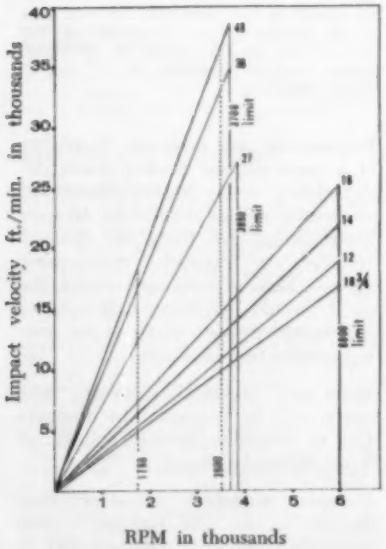
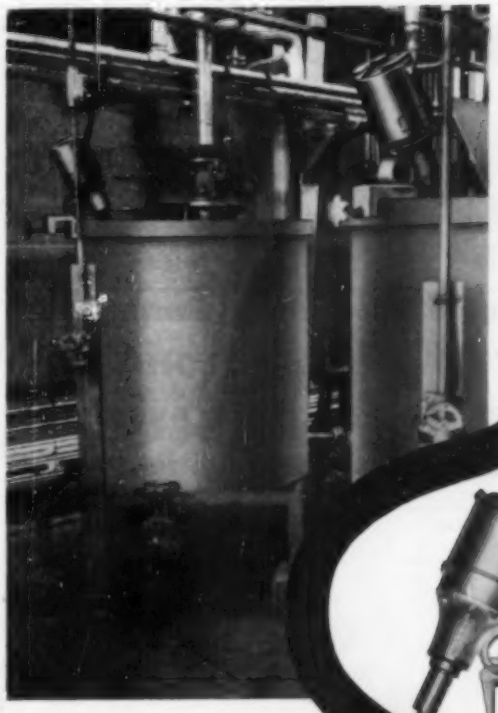


Figure 2. Impact velocities available with various rotor sizes and speeds (rotor diameters in inches).



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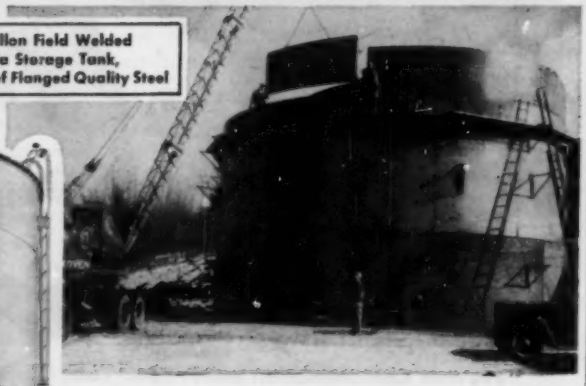

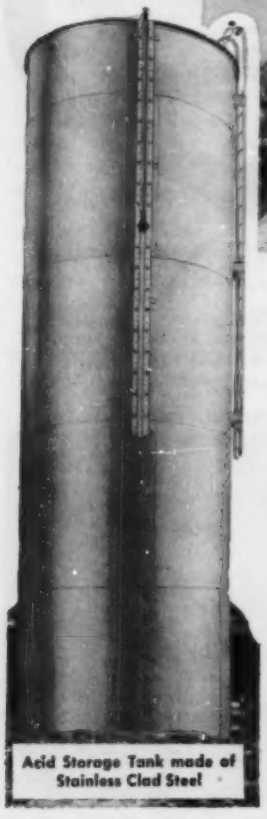

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overseas news

First installation abroad of the Miley Process for recovery and utilization of refinery sludge acid has gone into operation at the Norddeutsche Raffinerie in Hamburg, Germany. Design and knowhow for the unit was furnished by L. Sonneborn Sons, Inc.

Malines, Belgium, 12 miles north of Brussels, will be the site of a paint and lacquer plant to be erected by Du Pont de Nemours (Belgium), a Du Pont subsidiary to be formed in the near future.

Nearing completion at Moa Bay, Oriente Province, Cuba, are what is said to be the world's largest hydrogen sulfide plant with associated hydrogen plant (square cluster of buildings at lower right), and the largest sulfuric acid plant ever built at one time (three tanks and nearby structures at extreme left). The three units form part of the acid leach process by which Cuban American Nickel, subsidiary of Freeport Sulphur, will next summer start producing a nickel-cobalt concentrate for shipment to its Louisiana refinery, also under construction. Capacity of the project will be 50 million lb. of nickel metal and 4.4 million lb. of cobalt metal annually.

Engineering and economic feasibility of a multi-purpose nuclear plant, designed to generate 20,000 kilowatts of electricity, will be studied by Atomics International for Junta de Energia Nuclear, a Spanish government agency. Besides power generation, the plant would produce radioisotopes and would provide facilities for testing reactor fuel elements.

Seventeen chemical-recovery coke ovens will be furnished by Koppers Co. to Brazilian National Steel, of Volta Redonda, Brazil.

Uranium enriched to more than 99.97% in the 238 isotope is now available from AEC. The material, to be sold from Oak Ridge, is used in research for precision cross section neutron measurement, and in fission chambers for routine measurement.

future meetings

from page 130

Improve Technical Reports—Robert Gunning, Blacklick, Ohio.

Deadline for papers: January 17, 1959.

● St. Paul, Minn., Sept. 27-30, 1959, Hotel St. Paul. **A.I.Ch.E. National Meeting.** Gen. Chmn.: W. M. Podas, Asst. Rsch. Dir., Economics Lab., Guardian Bldg., St. Paul, Minn. Tech. Prog. Chmn.: A. J. Madden, Jr., Univ. of Minn. **Mixing**—J. Y. Oldshue, Mixing Equip. Co., Inc. P. O. Box 1370, Rochester 3, N. Y. **Size Reduction**—E. L. Piret, Chem. Eng. Dept., Univ. of Minnesota, Minneapolis 14, Minn. **Missile Construction Materials**—B. M. Landis, Gen. Elect. Co., Cleveland 12, O. **Physical Properties of Liquids**—S. E. Isakoff, Dupont Co., Eng. Dept., Expr. Sta., Wilmington, Del. **Molecular Engineering**—M. Boudart, Princeton U., Chem. Eng. Lab., Princeton, N. J. **Chemical Economics as a Unit Process**—M. H. Baker, 1645 Hennepin Ave., Minneapolis 3, Minn. **More Research for Your Dollars**—T. S. Mertes, Sun Oil Co., 1608 Walnut St., Philadelphia 3, Pa.

Deadline for papers: May 27, 1959.

● San Francisco, Calif., December 6-9, 1959. **A.I.Ch.E. Annual Meeting.** Gen. Chmn.: Mott Souders, Jr., Shell Development Co., 4560 Horton St., Emeryville 8, Calif. Tech. Prog. Chmn.: C. R. Wilke, Div. of Chem. Eng., Univ. of Calif., Berkeley, Calif. **Process Dynamics**—E. F. Johnson, Dept. of Chem. Eng., Princeton, Princeton, N. J. **Operations Research**—R. R. Hughes, Shell Dev. Co., Emeryville 8, Cal. **Progress and Problems in Jet and Rocket Combinations**—C. J. Marsel, NYU, University Heights, New York 53, N. Y. **Secondary Oil Recovery Methods**—F. H. Poettman, Ohio Oil Co., Littleton, Colo. **New Oil Sources—Shale Gilsonite, Tar Sands: Financing in the Chemical Industry; Raw Materials for the Chemical Industry; Turbulence and Turbulent Mixing; High Temperature: Thermodynamics, Reactions, Kinetics; Devices, and Materials; Electro-chemical Engineering-Process Design; Fundamental Aspects of Chemical Engineering in the Pulp and Paper Industry.**

Deadline for papers: August 6, 1959.

1960—MEETINGS—A.I.Ch.E.

● Atlanta, Ga., Feb. 21-24, 1960. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: Fred Bellinger, Ga. Inst. of Techn., 225 North Ave., N.W., Atlanta 13, Ga.

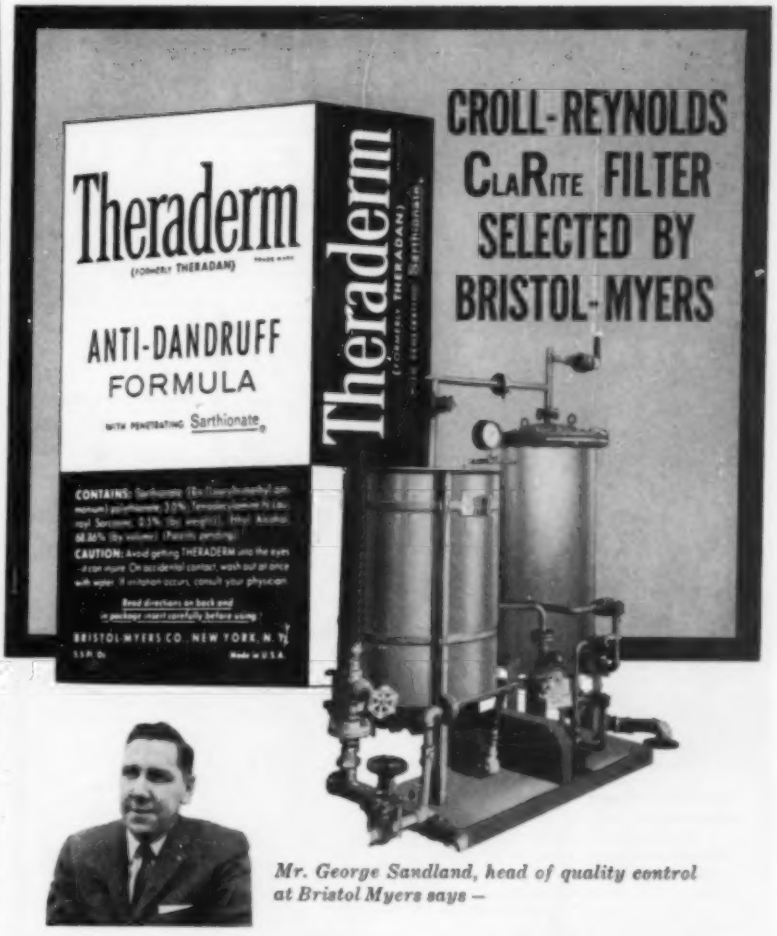
● Mexico City, Mexico, June 20-24, 1960. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: G. E. Montes, Nat'l Petrochemical Corp., P.O. Box 109, Tuscola, Ill.

● Tulsa, Okla., Sept. 4-7, 1960. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: K. H. Hachmuth, Phillips Petroleum Co., Bartlesville, Okla.

● Washington, D. C., Dec. 4-7, 1960. **A.I.Ch.E. Annual Meeting.** Tech. Prog. Chmn.: D. O. Myatt, Atlantic Research Corp., Alexandria, Va.

Unscheduled Symposia

Correspondence on proposed papers is invited. Address communications to the Program Chairman listed with each symposium below.
Chemical Engineering Process Dynamics as They Affect Automatic Control: David M. Boyd, 315 Ridge Ave., Clarendon Hills, Ill.
The Threatened Imbalance Between Chlorine and Alkali in American Chemical Industry: Zola G. Deutsch, Deutsch & Loonam, 70 E. 45th St., New York City 17.
Computers in Optimum Design of Process Equipment: Chen-Jung Huang, Dept. of Chem. Eng., Univ. of Houston, Cullen Blvd., Houston 4, Texas.
Financing for the Chemical Industry: Bernard Stott, First National City Bank of New York, New York, N. Y.
Chemical Engineers in Chemical Industry Management: T. P. Forbath, American Cyanamid Co., 488 Madison Ave., New York, N. Y.
Training on the Job for Industry: John Happel, Dept. of Chem. Eng., N. Y. University, University Heights, New York 53, N. Y.
Preparation of Catalytic Cracking Charge Stocks and Quality Criteria Therefor: Wheaton W. Kraft, Lummus Co., 385 Madison Ave., New York 17, N. Y.
Solar Energy Research: J. A. Duffie, Director of Solar Energy Laboratory, Univ. of Wisconsin, Madison, Wis.
Hydrometallurgy—Chemistry of Solvent Extraction: G. H. Beyer, Dept. of Chem. Eng., Univ. Mo., Columbia, Mo.



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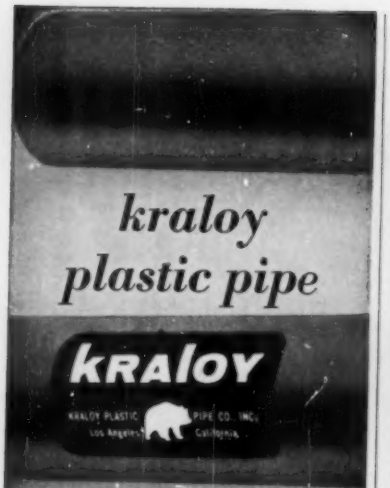

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Kerrigan, D., *Santiago, Chile*
Kimberly, William M., *Lincoln, Neb.*

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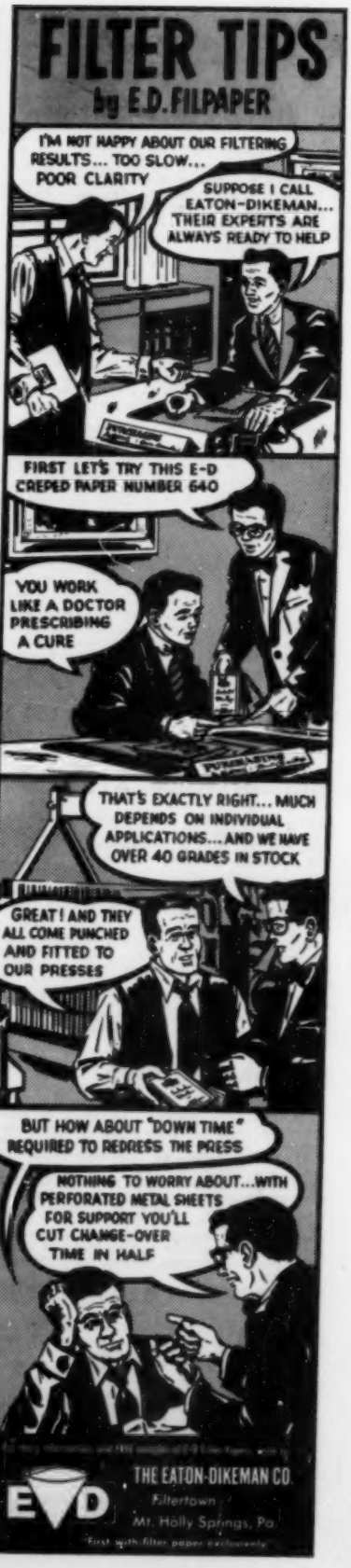
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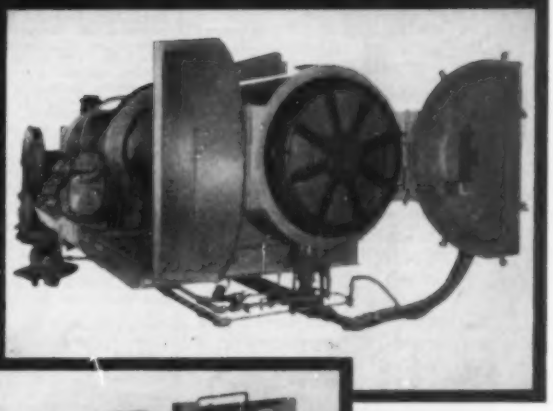

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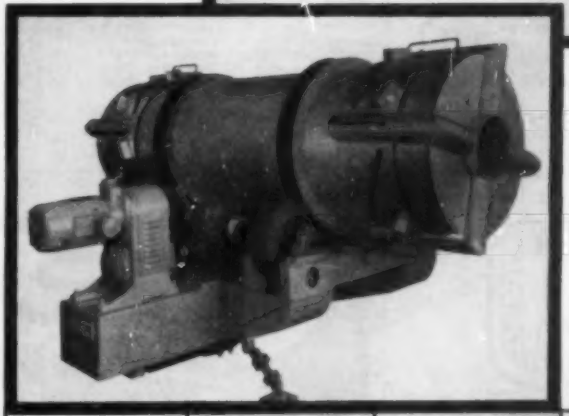

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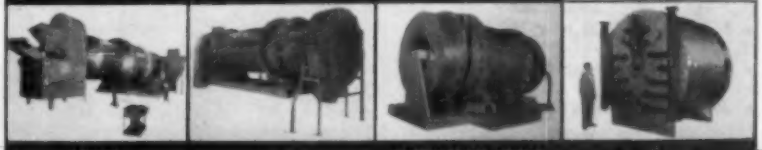

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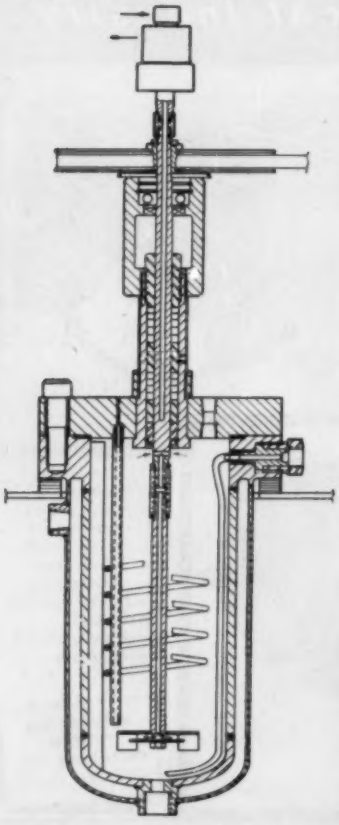

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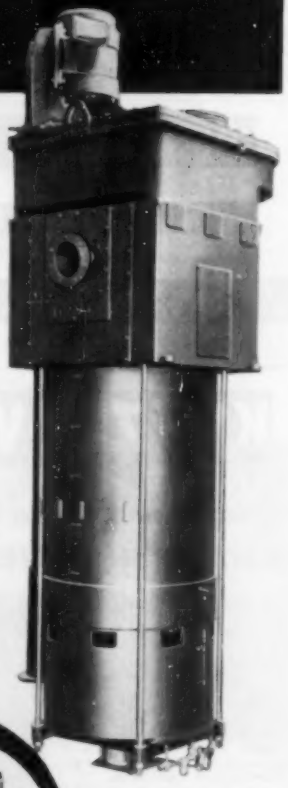

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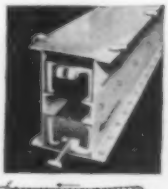

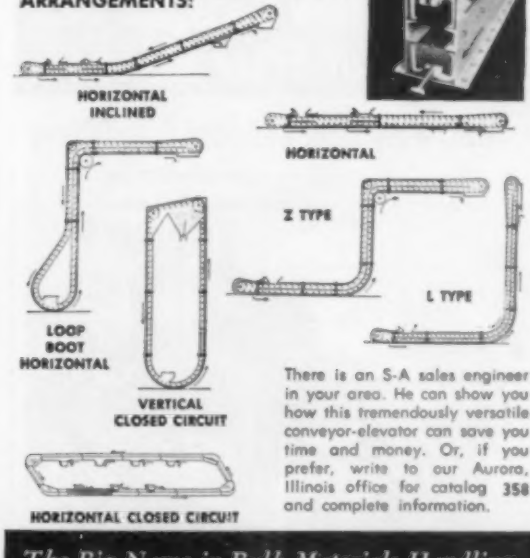

There is an S-A sales engineer in your area. He can show you how this tremendously versatile conveyor-elevator can save you time and money. Or, if you prefer, write to our Aurora, Illinois office for catalog 358 and complete information.

The Big Name in Bulk Materials Handling

STEPHENS-ADAMSON MFG. CO.

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Plants located in Los Angeles, Calif. • Clarksdale, Miss. • Belleville, Ont.

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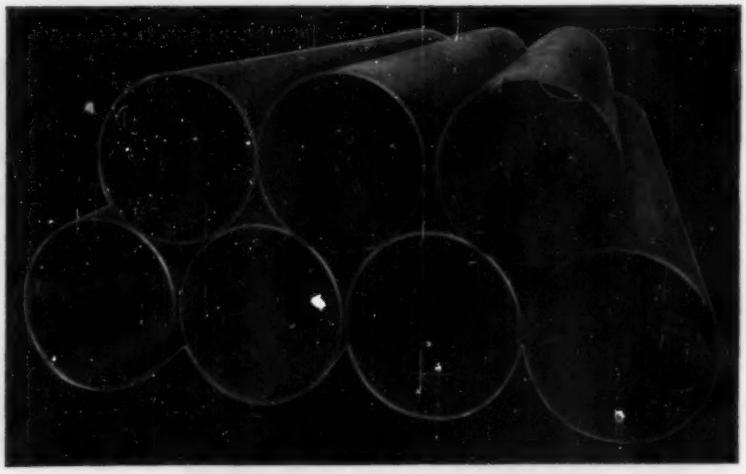

fabricated to meet your requirements

For high pressure, high temperature water lines . . . for sewage outfall lines . . . for any job requiring fabricated steel pipe of 14" O.D. or larger . . . you can depend on Posey's many years of engineering and manufacturing experience and complete production facilities. Write, wire or phone for information without obligation.

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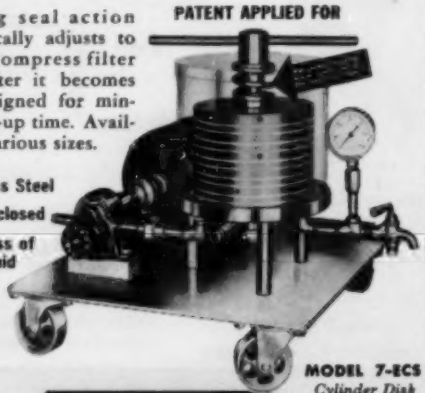
with New Ertel Cylinder Disk Filters

PATENT APPLIED FOR

• Spring seal action automatically adjusts to further compress filter media after it becomes wet. Designed for minimum set-up time. Available in various sizes.

▲ Stainless Steel
▲ Totally Enclosed
▲ No Loss of Liquid



MODEL 7-ECS
Cylinder Disk

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KUTZTOWN *Skill*

creates one of the largest BACKWASH VALVES ever built!

Made of Ductile Iron Grade 60 - 45 - 10

We used the Dry Sand method of molding in making this Backwash Valve (used in a Steam Turbine Condensor). Because of its massive size, it was more efficiently and economically made in a pit where there is no necessity for having large, cumbersome iron flasks.

Ductile Iron was used because it meets the needs for low-cost castings with mechanical properties approximately those of steel. Then too, it has qualities of machinability that are exceptionally similar to gray iron. Kutztown's craftsmen made the patterns, casting and finished machining.

14,000 lb. Backwash Valve Body being bored on a horizontal 4½" oversize G. & L. Main flange 101¼" O.D., 79½" I.D. Nozzle Flanges 59½" O.D., 48" I.D.

Whatever your requirements in castings may be, we are certain that you will find Kutztown services more than adequate. Your inquiry is most welcome!

We'll be happy to place your name on our mailing list to receive regular issues of the "Kutztown REVIEW."

KUTZTOWN FOUNDRY & MACHINE CORP.
KUTZTOWN, PENNSYLVANIA

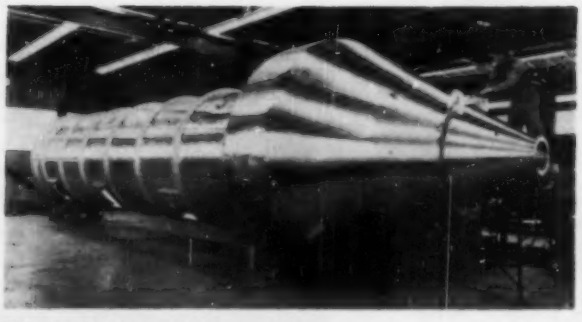
Ben Chapple, vice-president administration, U.S. Steel, alerts chemical engineering audience to the attack being made against the right of private enterprise to have profit-making as an objective, warns that commercialization of engineering projects is directly affected.

Here and there around Salt Lake City meeting.

Canyon Barbecue—At 9,000 ft., a little shortness of breath! (from left) Mrs. Moore; Mrs. McNally; R. J. McNally, general chairman; Mrs. Holbrook; J. D. Moore, asst. general chairman; George E. Holbrook, president A.I.Ch.E.

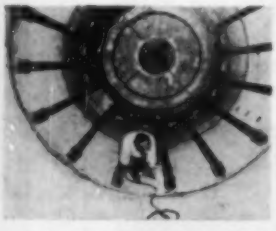
Indeterminate question: Who will finance research? Panelists (from left front, clockwise) W. G. Colman, National Science Foundation; Warren Lothrop, A. D. Little Co.; Henry Eyring, Univ. Utah; Gus Kinzel, Union Carbide; and Joseph W. Barker, Research Corporation, chairman.

Industrial close-ups

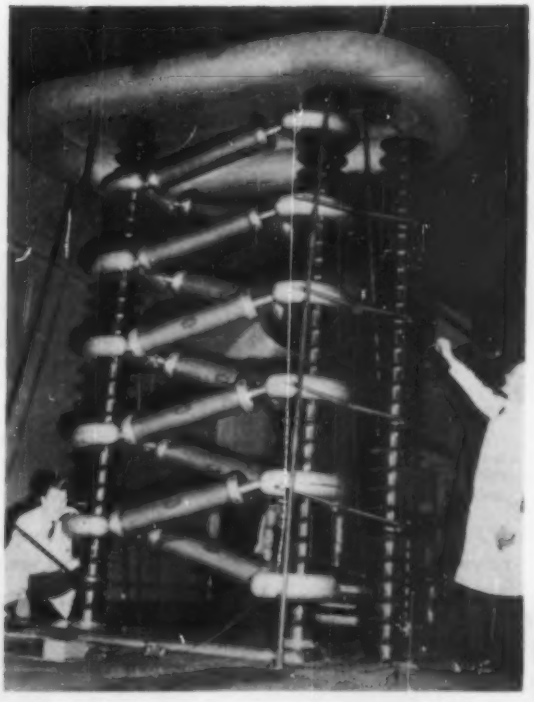


This 51-foot-long stainless steel spray dryer was recently installed at U. of Wisconsin for research on whole milk.

Rocket engines of Atlas ICBM being fired. Sustainer engine, center, boosters left and right.



Internal pipes are installed in first Hortonclad vessel by Chicago Bridge & Iron.



Univ. of Glasgow's million-volt Cockcroft-Walton accelerator, shown here, is used primarily for the determination of the energy levels in lighter nuclei.

Some of the 928 South Texas attendees enjoying the banquet.

Another Problem Solved by VAC-U-LIFT

HANDLING A TON OF BARRELS 85% FASTER WITH...

VAC-U-LIFT

Newly designed VAC-U-LIFT barrel handling unit attached to fork lift truck lifts four 500-lb. steel drums.

Unit is equipped with a dashboard control which allows the operator to lift or release 1, 2, 3, or 4 barrels collectively, individually, or in any combination.

Prior to using the VAC-U-LIFT barrel handler, barrels were rolled by hand from the dock into trucks. Each barrel required one man to roll it slowly and dangerously on edge. Tremendous savings of labor, time and money have resulted from the use of the VAC-U-LIFT barrel handler. The same unit with modification also handles other types of material. VAC-U-LIFT is also being used in conjunction with cranes and handles concrete slabs, steel plate, curved tank heads, pipe, glass, ceramic products, etc. Special custom built VAC-U-MATIC units have been produced as automatic turnover units and for automated material handling, from 20 tons down to a few ounces.

***VAC-U-LIFT SYSTEMS** quickly, economically and safely solve difficult handling problems regardless of weight, shape or size.*

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This brochure shows some of the many VAC-U-LIFT systems now in use. It explains how VAC-U-LIFT works and how you can take advantage of VAC-U-LIFT'S 3-step analyzation service without cost or obligation, write

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VAC-U-LIFT CO. Salem, Illinois

Modern computation, statistics, feature South Texas one-day

Last year's record attendance at South Texas All-day Technical Meeting was bettered by more than 100, as this year's registration totaled 928. More than 50 exhibitors displayed the latest in processing and control equipment. An address on "Then and Now"—a discussion of the views held by the framers of the Constitution compared to those held by our present political leaders, was delivered by J. A. Gooch at the evening banquet. Gooch urged the audience to work against the shifting of power from the local level to Washington.

The meeting consisted of a panel discussion on "Management and an Individual's Education, Advancement, and Future" chaired by F. M. Tiller of Univ. of Houston; two group (limited to 45) discussions; and four technical symposia. The group discussing Professionalism, under the gavel of J. J. McKetta, broadly considered the pro's and con's of compulsory and voluntary licensing.

With the admonition that our universities must do something drastic lest "outside" agencies force major changes in engineering curricula, W. W. Hagerty, Univ. of Texas, led off the Education panel, and went on to say that each new field of engineering interest has fostered a new engineering degree; this trend must be stopped. The emphasis should be towards the developing of a strong basic engineering curricula which is broad enough to enable the engineer to enter any field of engineering. Both industry and the universities have been slow in resisting the trend to

The big technical program led to much informal discussion in the lobbies outside the meeting hall.

W. W. Hagerty leads panel discussion Management and the Individual.

multi-engineering degrees.

Schools, continued Hagerty, should eliminate courses in shop mechanics, air conditioning, surveying, and the like, and teach more basic sciences. If parents realized that it costs $4000 to take high-school level subjects in college (a half-year's income, plus the cost of one semester in college) high school students would be encouraged to take algebra and trigonometry in high school.

Making a bid for an increase of the engineer's productivity by better use of his time, J. C. Kaskie, Monsanto, opened the symposium on Modern Computation Methods with his paper "Computer and the Engineer", in which he recommended forced planning, the farming out of non-scientific work, and the use of a "machine" to save computing time.

E. A. Clarke's, Humble Oil, "Introduction to the Analog Computer" described its functions, component parts, and its theory of operation in readily understandable language; including examples of applying the analog computer to specific chemical engineering problems. The problems involved in the application of digital computers to studies of transient and steady-state behavior of fractionators were covered in S. H. Davis', Rice Institute, "Digital Computer Calculations in Distillation". The rigorous plate-to-

continued on page 146

Industrial exhibits at the meeting drew large attendance from engineers present.

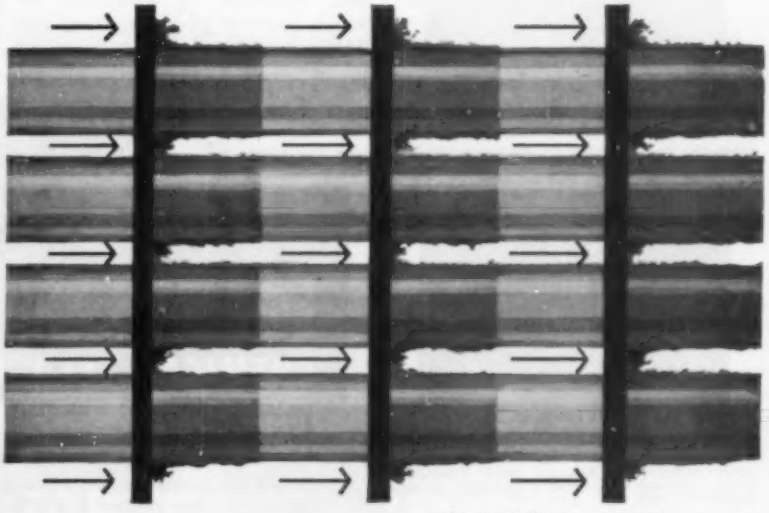
How a *Paracoil* "clean shave" gives you better heat transfer

Back and forth go the baffles . . . like blades . . . along the tube surfaces . . shaving away accumulations of fouling materials . . cleaning the heat exchanger . . . and giving process plants continuous, increased and better heat transfer.

This is the unique and principal feature of the Paracoil Self-Cleaning Heat Exchanger. Engineered with movable baffles, operated manually or by timed and automatic motor drive, stationary tubes are scraped and "shaved" free of fouling materials which are then carried away in the liquid.

The Paracoil Self-Cleaning Heat Exchanger eliminates the need to stop processing for cleaning purposes.

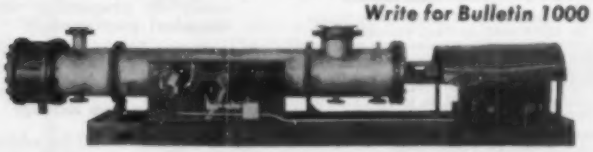
If you have a fouled heat exchanger problem, we may have the answer.



Davis Makes it — Better!

Below: Paracoil Vegetable Oil Chiller for converting a batch process to continuous cycle operation. Constructed of stainless steel and with an automatically timed, self-operating, self cleaning baffle assembly. The unit is presently improving product quality and rate of production in a vegetable oil processing plant.

Write for Bulletin 1000



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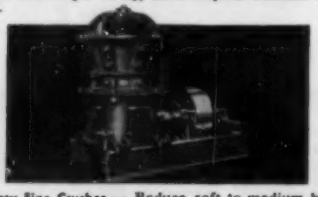
Sturtevant Construction Assures Long Mill Life at Top Loads

Sturtevant crushing and grinding machinery answers the long life top-load production problem for medium to small size plants. Many Sturtevants have been operating above rated capacities for more than 25 years, and *without a major repair.*

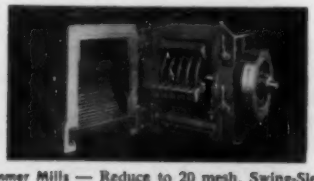
"Open-Door" design gives instant accessibility where needed — makes cleanouts, inspection and maintenance fast and easy. Machines may be set up in units to operate at equal quality and capacity.

Jaw Crushers — Produce coarse (5 in. largest model) to fine (¼ in. smallest model). Eight models range from 2 x 6 in. jaw opening (lab model) to 12 x 26 in. Capacities to 30 tph. All except two smallest sizes operate on double cam principle — crush double per energy unit. *Request Bulletin No. 062.*



Rotary Fine Crusher — Reduce soft to medium hard 3 to 8 in. material down to ¼ to 1¼ in. sizes. Capacities up to 30 tph. Smallest model has 6 x 18 in. hopper opening; largest, 10 x 30 in. Non-clogging operation. Single handwheel regulates size. *Request Bulletin No. 063.*

Crushing Rolls — Reduce soft to hard 2 in. and smaller materials to from 12 to 20 mesh with minimum fines. Eight sizes, with rolls from 8 x 5 in. to 38 x 20 in.; rates to 87 tph. Three types — Balanced Rolls; Plain Balanced Rolls; Laboratory Rolls — all may be adjusted in operation. *Request Bulletin No. 065.*



Hammer Mills — Reduce to 20 mesh. Swing-Sledge Mills crush or shred medium hard material up to 70 tph. Hinged-Hammer Pulverizers crush or shred softer material at rates up to 30 tph. Four Swing-Sledge Mills with feed openings from 6 x 5 in. to 20 x 30½ in. Four Hinged-Hammer Pulverizers with feed openings from 12 x 12 in. to 12½ x 24 in. *Request Bulletin No. 084.*

**Reports Manager W. Carleton Merrill concerning Sturtevant Swing-Sledge Mill at James F. Morse Co., Boston.*

STURTEVANT
MILL COMPANY
135 Clayton St., Boston 22, Mass.

local sections

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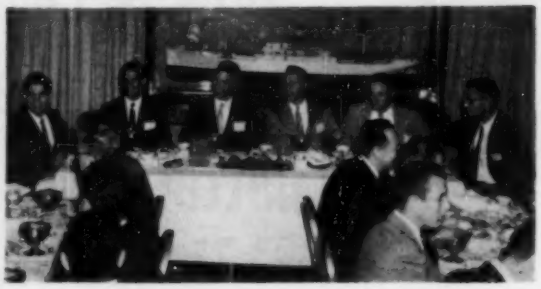

General Committee at speakers luncheon. L. to r.: G. Gibbs, G. E. Hill, K. S. McMahon, C. L. Umholtz, J. C. Upchurch, G. Cummings.

South Texas Meeting

continued from page 144

plate calculations, heretofore considered too tedious, time consuming, and impractical to compute to a high degree of accuracy, can now be made on high-speed digital machines. Precise calculations for four types of vapor-liquid equilibria were performed and compared by H. Bonner and E. Eckhom, Bonner & Moore, and The Pace Co., respectively.

A new absorption refrigeration system, developed by Southwest Research Institute, which improved performance, reduced fuel consumption and cooling water needs, was described by Swearington and Whitlow of SWI to open the General Papers session. An improved de-asphalting process developed at Humble Oil, and now in use to recover catalytic cracking feed stock from crude residuals was explained in a paper by J. E. Lawson, J. P. Peet, and N. P. Peet of Humble. That the formation of bubbles at submerged orifices could be correlated with the physical variables of the system, by the application of Newton's second law to the bubble, just prior to its release from the orifice, was demonstrated by W. B. Hayes

continued on page 148

for more accurate chemical feed control at LOWER COST use a...

"Packaged"

NEPTUNE

CHEMICAL FEED UNIT

JUST PIPE-IN . . .
PLUG-IN . . . AND OPERATE!

You'll get positive, accurate proportioning of chemicals when you use a NEPTUNE "packaged" chemical feed unit. That's because tank, agitator and pump are designed and built into one precisely-engineered chemical feed system. In addition to lower first cost and minimum upkeep, longer life is assured by 316 stainless steel piston, valves and ball checks.

- **simply designed pump can be regulated easily to proportion exact quantities of chemical continuously**
- **agitator keeps precipitates from settling, assuring constant solution strength**
- **Y-type strainer removes harmful solids, prevents pump damage**

Tank, agitator and pump are combined in one smooth operating system that precisely proportions anything from treating chemicals, such as calgon, to petroleum distillates.

Write, wire or call for additional details and let us bid on your requirements.

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chemical proportioning pumps and sump pumps

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DEMINERALIZED WATER *from* TRICKLES *to* TORRENTS

99.9999% Pure Water For Pennies!

The Exchangion Deionizer (shown at right) is shipped ready for ion exchange and adsorption problems, or to supply demineralized water. Seven sizes of these all-plastic regenerative-type deionizers offer flow rates of 5 to 120 gals. per hr. Bonus values include transparent construction which permits observation of resins during all phases of operation. Recommended for applications including lab research, sugar solution purification, conversion of salts to acids, chromatographic separations, color removal, metal concentration by products recovery, oxygen removal, etc. Prices start at $43.02.

Exchangion Model No. 60. Complete with clamp board.

Cat. No. DI-50

TABLE MODEL — Connects instantly to any water tap up to 60 gals. per hr. New direct reading meter shows effluent quality in parts per million. A laboratory essential. Research grade pure water on tap. Water Master No. DI-50 .....$59.50

CABINET MODEL—up to 100 gals. per hr. Houses purifying cell of mixed-bed ion exchange resins. When built-in purity light shows resin exhaustion, purifying cell is returned to factory for regeneration. Greatest convenience and economy. Demineralized water at faucet-flow delivery. D-Ion Master Cat. No. 8120 .....$210.00 up.

Cat. No. 8120

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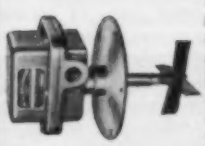
HANDLING WITH

ROTO-BIN-DICATOR

LOWEST COST MODERNIZATION



If you store, process or pack bulk material you can have automatic control of handling at nominal cost with a few Roto-Bin-Dicator bin level indicator units. Prevent waste, protect equipment, save repairs. Big savings year after year. U. L. Listed Standard and Explosion-Proof Units.

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Many Money-Saving Applications — The Smith-Dolan System simplifies and upgrades work quality in numerous applications ranging from welding to forming and annealing. Units are available for 60 cycle heating in capacities ranging from 10 to 150 KVA . . . for 400 cycle heating . . . resistance heating. Pre-engineered with complete instrumentation, accessories.

"On Trial" Installations on Rental Basis — Prove the many Smith-Dolan advantages in your own plant without capital investment. Write, wire or phone.

Electronic recording gives permanent charts of heat run on this standard Smith-Dolan model. Coils permit work at 50 feet or more from unit. Eye hooks provide for easy handling by crane. Products ranging from a fraction of an inch to 10 feet in diameter can be heat treated on the job.

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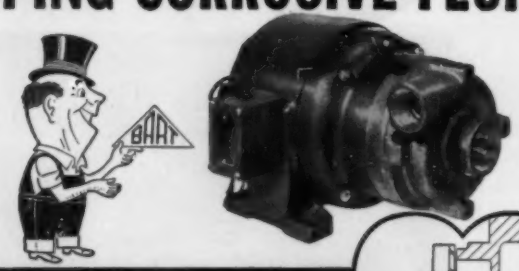
now! greater ***safety*** *and* ***efficiency*** *in*

PUMPING CORROSIVE FLUIDS



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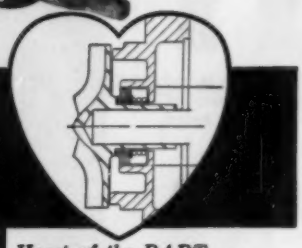
FLEX-SEAL

CENTRIFUGAL PUMPS



At last—a full line of pumps *specifically designed* to handle corrosive and abrasive fluids in the 1 to 80 GPM range, at heads to 70 feet.

No longer need you cut down bigger pumps in range and lose efficiency—or put up with undependable smaller pumps.

Bart pumps have fewer parts to wear or get out of order. 12 models, each in two materials . . . Type 20 Stainless Steel or Hastelloy C . . . cover almost every application.

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Heart of the BART . . . the exclusive Flex-Seal!

Effectively minimizes a long-prevalent basic weakness of centrifugal pump design. Self-adjusting to wear. Needs no external lubrication. Carbon stator with ceramic seat, unexcelled for long wear—or zircon filled Teflon stator with Stellite or Worthite seat for severest corrosive service.

Choice areas for commission representatives available. For details, inquire:

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BAUER SWING HAMMER BREAKER FOR COARSE GRINDING AND CRUSHING

- Heavy duty mill with wear-resisting swing hammers
- Handles friable material up to 10" lump size
- Magnetic protection optional
- High carbon steel grate bar spacing or screens to meet your needs
- Flywheel absorbs shock loads
- Write for complete information

THE BAUER BROS. CO.

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local sections

from page 146

and C. B. Holland, Texas A&M. D. M. Himmelblau, Univ. of Texas, presented a universal solubility correlation for inert gases in water to close the symposium.

The orientation process which should be completed before a great deal of time and money is spent on a plant or research problem was described in "Defining the Problem" by T. L. Rapp, Monsanto, for the "*Use of Statistics in Research and Production*" symposium opener. How expected accuracy and reproductibility can be affected by a random error, and how a knowledge of the random error may be used to determine the expected results was illustrated by R. A. Stewart, Shell Oil. H. F. Smith, DuPont, explained the basic philosophy behind the Box-Wilson method of industrial experimentation to determine optimum operating conditions.

Engineers and management, economic aspects of rocket industry

Because post-war expansion in the Chemical Process Industries was so spectacular, it will be hard to maintain the same pace, commented Ralph Landau, Executive V.P. of Scientific Design, at the **New York Section** in September. The rate of growth of the CPI has recently diminished, although the industry is not really short of capital. Outside the CPI, Landau continued, disillusionment has crept in. Wall Street no longer recommends CPI stocks as growth stocks. There has been a lot of criticism of the industry, says Landau, some of it justified, most of it unjustified. In answer to *Fortune* magazine's claim that the CPI has not produced a new research idea in years, Landau produced a list of some 30 new chemical developments that have reached the market in the post-war years. . . . 25 of which were specifically developed by U.S. firms.

Landau directed many of his comments at management; ranging from increased pay for scientists and incentives for inventiveness, to promotion of scientists to top administrative posts. Landau suggested the following as what management might do to improve the position of the technical man and scientists:

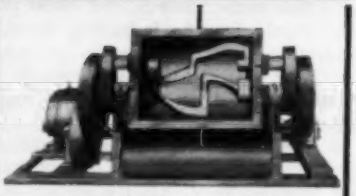
1. Good pay . . . not now sufficient

continued on page 150

CHEMICAL PROCESSING MACHINERY

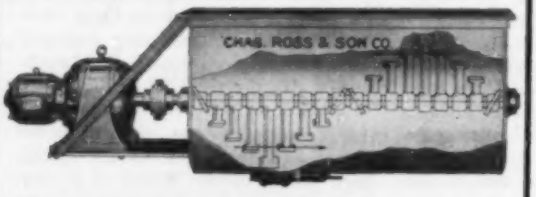
gives better results in less time!

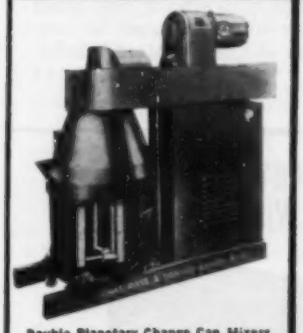
Rubber Cement Mixers
100 - 1000 Gal. sizes



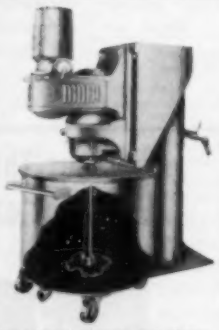
Heavy Duty Double Arm Kneaders
1 pint - 150 Gal. sizes

Rubber Reclaiming Mixers
100 - 1000 Gal. sizes





Double Planetary Change Can Mixers
1 - 150 Gal. sizes



High Speed Change Tank Mixers
80 - 250 Gal. sizes

Heavy Duty Paste Mixers
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Almost a century of furnishing *Heavy Duty* dependable equipment to the chemical industry.

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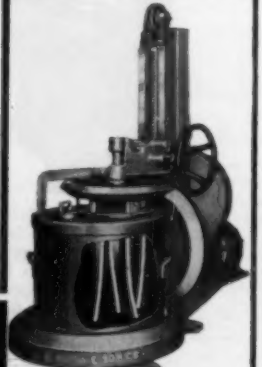

Heavy Duty Change Can Mixers
8 - 60 Gal. sizes

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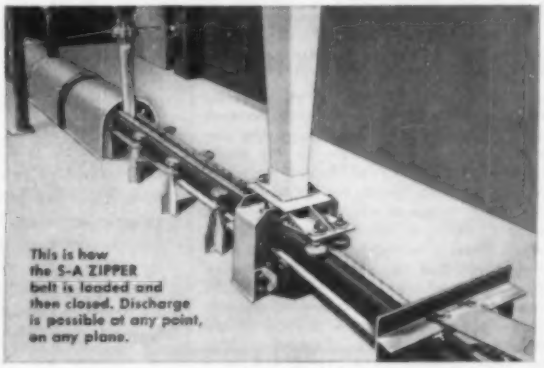


This is how the S-A ZIPPER belt is loaded and then closed. Discharge is possible at any point, on any plane.

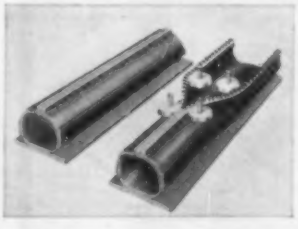
NO SEGREGATION — NO DEGRADATION OF MATERIALS

Bulk materials — granular, flaky, pulverized or small lump, can be conveyed or elevated in any plane, entirely enclosed and protected by S-A ZIPPER belt conveyors and elevators. The most delicate materials are moved swiftly and economically without degradation or separation. The ZIPPER conveyor is the only system which gently wraps its contents, moving them to a destination where the belt unwraps and gently deposits its contents.

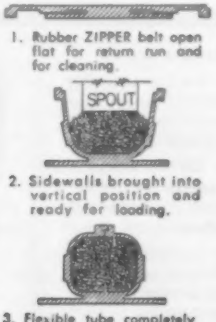
ZIPPER conveyors require no casings, will carry long distances in numerous flexible arrangements. The belt opens to receive material, zips closed sealing its load in a dust-tight casing which moves over a system of guide rollers and pulleys to discharge.

Exclusively an S-A product, the ZIPPER is ideal for products requiring gentle, clean handling.

For additional information write for Bulletin 349.



Section view thru endless ZIPPER belt shows how load is completely enclosed. Belt is spread, meshed and locked by rollers.



1. Rubber ZIPPER belt open flat for return run and for cleaning.

2. Sidewalls brought into vertical position and ready for loading.

3. Flexible tube completely closed for conveying and elevating.

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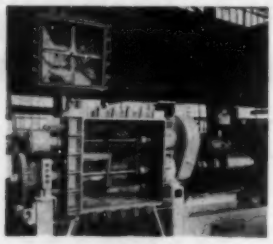

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Adapted to an infinite number of mixing tasks, materials and capacities. Has many optional features: Tooth-cut edge mixing blades and stationary shredder bar available for the disintergration and blending of fibrous materials. Special jackets and cored mixing blades for precise batch temperature control, either for more rapid heating or cooling. Removable stainless-steel, nickel or monel bowl liners and hard wearing blade lips for abrasive or corrosive materials. Adaptations for vacuum mixing to retrieve solvents, remove extraneous moisture (batch drying) or for mixing with vacuum tight quick clamping covers.

WRITE FOR ILLUSTRATED BULLETIN NO. B-12

GRUENDLER CRUSHER & PULVERIZER COMPANY

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from page 148

differential in pay between starting grades and top grades . . . able technical and scientific people should be on a level with administrative personnel.

2. Scientists in administration . . . promotions into top positions are rare . . . research directors of most companies report to administrators too low on the staff . . . must bring technical men into top circles for better understanding at that level. . . if he's the "right man", the Ch.E. is the ideal liaison between management and scientists.

3. Research is too concentrated . . . top technical people who do run research do not have market evaluation people working for them . . . many companies find it obnoxious to bring in technology from "outside"; however, it is almost invariably cheaper to bring in outside help than to spend money researching.

4. *Know the field* the company is working in, and develop along those lines (DuPont, Dow, UCC) as opposed to opportunists . . . there are still too many fields that are still "arts".

5. Should be more "blue sky" research; not crash programs.

6. Industries should encourage universities to "promote the Ph.D. . . . can help research scientists do this by making their facilities available to their personnel doing thesis work . . . increase salary differentials . . . make more use of *technicians*.

On the subject of research, Landau maintained that the best research is probably done within relatively small groups.

Scholarship in general

Why do certain high schools in the U.S. consistently graduate large numbers of scholarship winning students? This was the question R. F. Marschner of Standard Oil of Indiana tried to answer at a recent **Central Ohio** (*J. H. Oxley*) section meeting. In his capacity as president of an Illinois high school district Board of Education, Marschner had the opportunity to survey 38 high schools throughout the country which produced the largest number of National Merit Scholar-

continued on page 154

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it will be done **best** with
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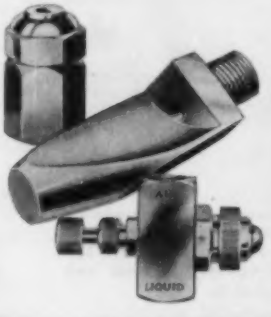

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Small Chemical operation in major manufacturing corporation experiencing rapid growth needs a man who can make market contacts and surveys; don overalls to get first hand information on product applications; carry out laboratory development; field test new products and assist in their merchandising and promotion. Excellent position for young, capable man looking for advancement. Locations 100 mile radius of Chicago. Send resume and record of earnings. Box 4-11.

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We need a competent man to represent us in the Midwest selling heat transfer apparatus and distillation columns to the Chemical and Petroleum Refining Industries. He should have most of the following qualifications:

1. Engineering degree or its equivalent
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This is your opportunity to join a well established Company in a position of responsibility.

Send complete resume and salary requirement to:

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Personnel Department
VIRGINIA-CAROLINA
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CHEMICAL ENGINEER—M.Ch.E., age 36, family. Fourteen years' experience in petroleum, chemical and synthetic fiber industries includes research, development, pilot plant, plant assistance, economic evaluations, and consulting. Desire responsible, challenging position. Box 7-11.

CHEMICAL ENGINEERING EXECUTIVE — Former Plant Engineer, Director of Engineering, Staff of Executive, Research V.P.'s large chemical company. Versatile, broad background. M.S.Ch.E. Age 39. Prefer New York-Philadelphia area, others considered. Present salary $12,000. Box 8-11.

PROJECT MANAGER—M.S.Ch.E. Ten years' experience: Plant, process, equipment design. Economic evaluations, purchasing and contract negotiations. Proven ability directing engineering and construction forces for $5,000,000 project. Desire management position in Engineering, Production, or as Executive Assistant. Box 9-11.

continued on page 152

An Invitation To Join ORO...Pioneer In Operations Research

Operations Research is a young science, earning recognition rapidly as a significant aid to decision-making. It employs the services of mathematicians, physicists, economists, engineers, political scientists, psychologists, and others working on teams to synthesize all phases of a problem.

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SITUATIONS WANTED

continued from page 151

SALES EXECUTIVE — Successful record licensing, engineering, construction sales petroleum and chemical industries. M.S.Ch.E., M.B.A. top schools. Twenty years' experience major oil company and leading engineer-contractors. Interested challenging opportunity V.P. or Sales Manager level. Box 10-11.

CHEMICAL ENGINEER — B.Ch.E., Age 32, single. Eight years' experience, R & D, production supervision in textiles, polymers, atomic energy and heavy organics. Seeking supervisory position in chemical manufacturing. Salary negotiable. Box 11-11.

CHEMICAL ENGINEER—Age 32. M.S.Ch.E. Eight years' experience in sale of Chemical Process Equipment. Seeking position in Equipment Sales, in District Sales Office, or as Manufacturer's Agent, or Sales Management in Midwest. Present income $10,000 range. St. Louis Area preferred. Box 12-11.

MANUFACTURER'S REPRESENTATIVE — Established twelve years ago. Well known in Chemical Engineering circles. Two man organization—both Graduate Chemical Engineers. Twenty-one years' combined experience in sale of Chemical Process Equipment. Desire established Process Equipment line to represent in Missouri and Southern Illinois. Box 13-11.

PROJECT MANAGER — Experience includes complete charge of projects to 20 million. Detailed process, equipment design, instrumentation, procurement, construction. Experience covers organics, petrochemicals, fertilizers (Urea). Seeking challenging position as Project Manager or Chief Engineer. Present salary $14,000. Box 14-11.

CHEMICAL ENGINEER—M.S. Eighteen years' experience in process design and improvement, economic evaluations, construction and subcontract administration, operations, and project engineering in the process industries. Seeking position in production management or engineering administration. Box 15-11.

CHEMICAL ENGINEER—B.S. 1940, age 40, single. Broad background of eighteen years' experience with a large chemical company, includes process development, pilot plant supervision, economic studies, technical personnel recruiting, institutional advertising, and digital computer operation. Desire position with aggressive, growing company. Locations: open, but slight preference for west coast, Texas or foreign. Box 16-11.

PROJECT COORDINATOR — M.S.Ch.E., B.S. Chemistry, P.E.: age 30. Six years' experience in project coordination, project engineering and sales. Seek position requiring broad experience (petrochemicals, synthetic fibers, Government R & D). Presently unemployed. All replies answered. Box 17-11.

PROCESS ENGINEER—Seventeen years' experience in economic analyses, long range planning, process development, process design, and initial operation of petroleum chemical plants and oil refineries. Responsible charge of projects for engineering contractor and supervisory experience over plant engineering department for operating company. Desire position in operating company, either in engineering or production. Box 18-11.

CHEMICAL ENGINEER—B.Ch.E., 1953, age 27, veteran. Four and one-half years' diversified engineering experience including polymer development and consulting. Development, design, pilot plant, plant layout and startup. Evening student, N.Y.U. pursuing M.I.E. Seeking R & D position with increasing opportunities in operations research. Salary open. Box 19-11.

SUPERVISING CHEMICAL-MECHANICAL ENGINEER or PLANT SUPERVISOR —P.E. Thirty years' experience in petrochemical plants including research and development, design, construction and operation. "Q" cleared. Age 54. Present income $15,500. Box 20-11.

CHEMICAL ENGINEER—Experience in process design, project engineering and plant construction. Petroleum and organic chemical fields. Age 30, married. Seek responsible position in engineering department of small company. Location immaterial. Box 21-11.

CHEMICAL ENGINEER—M.S.Ch.E., age 24, single, honors, references. Two years' experience in elastomer process development; process economics; cost estimation; plant start-up. Desire opening providing experience in process/product development, technical sales, or market analyses, leading to responsible position. Prefer Northeast, will consider other. Box 22-11.

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ACADEMIC POSITION — FEBRUARY 1959. Assistant Professor of Chemical Engineering. Permanent position for young man with doctorate in Chemical Engineering, teach undergraduate subjects. Excellent facilities, new building, growing department. Minimum salary $6,000 for nine month contract. Teaching or industrial experience desirable. Opportuunities for summer employment. Write Chairman, Chemical Engineering Department, Mississippi State University, State College, Mississippi.

SITUATIONS WANTED

CHEMICAL ENGINEER—age 39. Six years' process design, liaison with production, in central staff engineering. Three years process development and liaison with research. Eight years' project engineering, field operations, in construction. Desire project engineering or staff position. Box 23-11.

CHEMICAL ENGINEER—B.Ch.E., age 28, married, veteran. Tau Beta Pi. Six years' diversified experience in process development and improvement, pilot plant supervision including synthetic elastomers. Also some product development and design. Desire progressive position. Will relocate. Available immediately. Box 24-11.

CHEMICAL ENGINEER—M.S.Ch.E., 1952. Seven years' experience in technical and economic evaluations, had design responsibilities in connection with chemical processes of AE plants. Interested in design studies related to new processed or plant technical work improving old ones. Box 25-11.

CHEMICAL ENGINEER—B.S.Ch.E. with thirteen years' process development and production experience in pharmaceuticals, inorganics, organics and specialties. Seek permanent position as process or production engineer with progressive company. Prefer New Jersey location. Married, family. Box 26-11.

PRODUCTION MANAGEMENT—B.S.Ch.E., age 32. Eight and one-half years' experience: Group Supervisor, Departmental Superintendent, Production Superintendent. Second in command of 175 man chemical plant start-up and operation. Extensive process development. Organized maintenance department. Available immediately for responsible management position. Box 27-11.

PROJECT ENGINEER—Ch.E. Diversified experience and know-how in petrochemical plant design: process calculations, project engineering, start-up. Young (30), energetic, ability to get things done. Tau Beta Pi. Salary requirements: $14,000. Location: New York City or metropolitan New Jersey. Box 28-11.

ADMINISTRATIVE SALES—Twelve years active sales experience in plastics, resins, chemicals and textile fibers. Have administrative experience and background in research and development. Familiar with entire East Coast and Mid-Western areas. Age 38. B.Ch.E., M.B.A. Box 29-11.

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Chemical Engineering Progress

CHEMICAL ENGINEER—Assistant department head level. R & D. manufacturing. Experience in development and manufacture of organic and inorganic chemicals, petrochemicals, food, pharmaceuticals. Staff administrative experience in technical-financial analysis and planning. Box 30-11.

CHEMICAL ENGINEER—M.S.Ch. E., age 24, married, veteran. Excellent background in advanced mathematics. Experience in process design. Seeking responsible position with company needing an alert engineer for research and development or process analysis work. Box 31-11.

PRODUCTION MANAGEMENT ENGINEERING—Age 40. M.Ch.E. Fifteen years' experience in chemical food processing and aerosol packaging plants. Plant manager, process engineer, process evaluation and development, production supervision. Seeking responsible position in production management. Present salary $11,000. Box 32-11.

CHEMICAL ENGINEER—B.S.Ch.E., with nine years varied refinery, synthetic fiber, rubber experience, process engineering, startups, investigations, administrative engineering. Married, family. Seeking supervisory position in Production or Technical with aggressive company. Box 33-11.

CHEMICAL ENGINEER — Ph.D., M.S. Phys. Chem., P.E. Age 38, family. Eight years' industrial R & D experience: preparation and spinning polymers; distillation; fermentation. Teaching experience. Box 34-11.

ENGINEERING ADMINISTRATION — B.S. in chemical engineering, age 35, with courses in economics and ten years' diversified experience in the chemical process field. Desire administrative position in developing, promoting and marketing industrial products. Box 35-11.

CHEMICAL ENGINEERING TEACHING POSITIONS AVAILABLE

A list of chemical engineering teaching positions in schools and universities in the United States and Canada on Oct. 20, 1958 may be obtained from the Secretary, A.I.Ch.E., 25 West 45th Street, New York. Salary data and rank of position are given.

ADVANCE INFORMATION

The Situations Wanted portion of this Classified Section is preprinted and mailed a few days in advance of publication, to Employment Directors. Send names of individuals who should be on mailing list to: Miss E. Adelhardt, Chemical Engineering Progress, 25 W. 45th Street, New York 36, New York.

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Advertisements in the Classified Section are payable in advance at 24c a word, with a minimum of four lines accepted. Box number counts as two words. Advertisements average about six words a line. Members of the American Institute of Chemical Engineers in good standing are allowed one six-line Situation Wanted insertion (about 36 words) free of charge a year. Members may enter more than one insertion at half rates. Prospective employers and employees in using the Classified Section agree that all communications will be acknowledged; the service is made available on that condition. Answers to advertisements should be addressed to the box number, Classified Section, Chemical Engineering Progress, 25 West 45th Street, New York 36, N. Y. Telephone COlumbus 5-7330. Advertisements for this section should be in the editorial offices the 10th of the month preceding publication.

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local sections

from page 150

ship finalists. The answer he presented was complex, involving many factors, each of which he explained.

Some of the conclusions he cited included: the types of communities in which the schools are located (more than half of the schools are in suburban areas); the caliber of the pupils assigned to the schools (most of the schools had students with ability levels well above the country-wide average); the teachers sought out and employed; the emphasis the schools placed upon the scholarships. In almost all cases the standards were uncompromisingly high. These are exemplified by such statements as "We started high, and raised our standards from year to year," "We simply refuse to accept mediocrity."

Also Meeting

Labor-management arbitration, much of it concerning the local-area chemical and refining industries was discussed by E. E. Hilpert of the U.S. Arbitration Service at the **Alton-Wood River section** *(J. G. Huddle)* in September. . . . rocket propellant systems, including the use of chemical and nuclear energy, and their design to suit tactical needs were described at **Chicago section's** *(R. L. Opila)* season opener by V. J. Cushing of Armour Research. . . . the Dowtherm film on engineering and economic aspects of liquid and vapor phase heat transfer was featured at the **Pittsburgh section** *(V. N. Hurd)* in October. . . . the first meeting of the season for the **Rocky Mountain section** *(Bert K. Larkin)* featured a Chamber of Commerce film on Denver "One Mile Nearer to Heaven." . . . the effect of the St. Lawrence Seaway project on the Great Lakes seaports, and on the chemical industry in the Michigan area, was conjectured by Carl Stettin of the Port of Detroit Authority at **Detroit section** *(H. W. Grubb)* in October.

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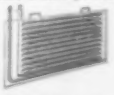
The Dean Thermo-Panel Coil gives you much more heating surface per square foot than does the old-style pipe coil. It usually costs considerably less — weighs less — is more efficient — more economical — and is more quickly installed and removed for cleaning. It is superior in every way. Below we show a standard flat Dean panel.

ALL CHEMICAL ENGINEERS are invited to ask for complete data and prices on the Dean Thermo-Panel Coil which TAKES THE PLACE of old-fashioned pipe coils.



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*DuPont's trade name for tetrafluoroethylene

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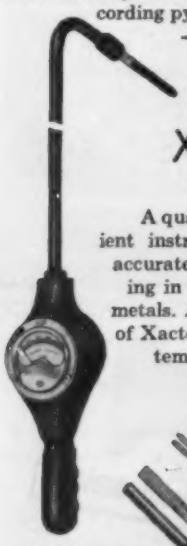

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news and notes of A.I.Ch.E.

Coming soon—A.I.Ch.E. hopes to publish before the end of this year several important additions to its list. Copy has been turned over to us by the Research Committee on a bubble-tray design manual for prediction of fractionation efficiency. We expect to have copies for the Cincinnati meeting in December. Then, early next year, we shall have the pump manual ready, the work of a subcommittee of the Equipment Testing Procedures Committee, under R. L. Jacks. The Chemical Engineering Education Projects Committee has turned in an extensive manuscript on problems in stoichiometry. Monograph and Symposium Series volumes are being currently edited that cover the following subjects: Nuclear Engineering—Parts V and VI; Computation in Chemical Engineering; Adsorption, Dialysis, and Ion Exchange; Heat Transfer—Chicago; Diffusion and Chemical Kinetics; Pollution Control by In-plant Measures. The above, added to the three volumes which we turned out for the Fiftieth Anniversary: "Chemical Engineering in Industry," "Chemical Engineering Around the World," and "Highlights" of the First Fifty Years of the American Institute of Chemical Engineers" (which are still for sale at $10 per set for members), make for quite a publishing program for A.I.Ch.E.

The Sections Activities Committee Meeting at Cincinnati is important to every Local Section. Representatives will frankly discuss A.I.Ch.E. policy, events, ideas, and building drive, under the guidance of Donald L. Katz . . . Details will be sent to Local Section chairmen.

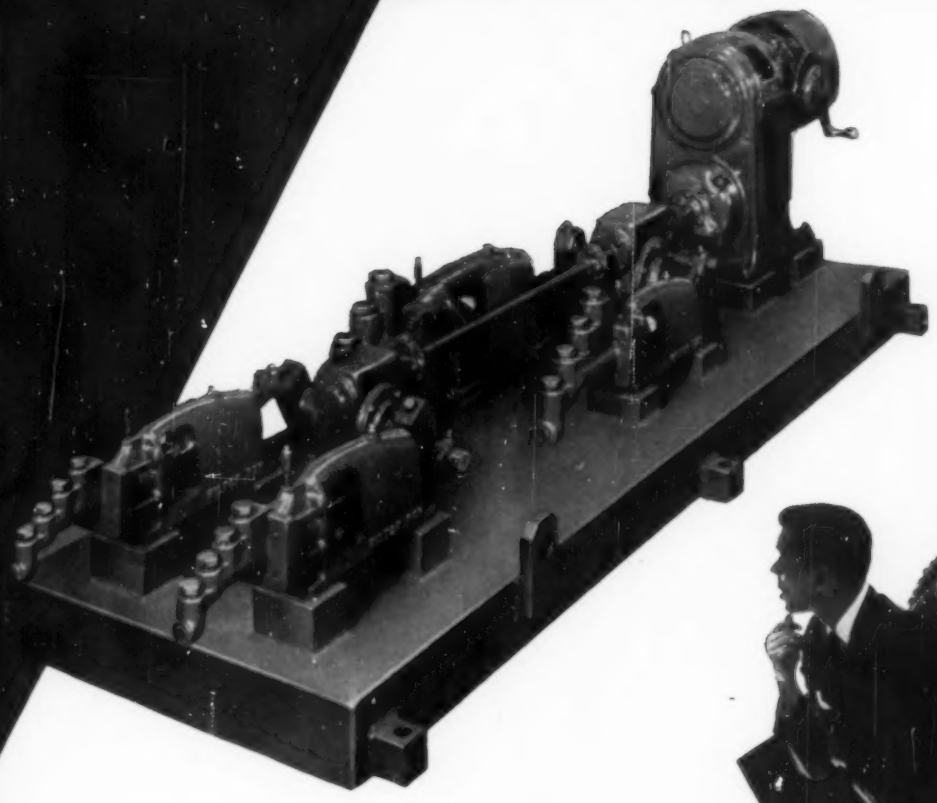
U.P.A.D.I. at its recent meeting in Montreal passed the following resolution: " . . . to thank and compliment both the Committee on Suggestions and on Engineering Education, and especially their Chairmen, Engineer Walter E. Lobo and Engineer Ralph Morgen respectively, for the splendid job done by their Committees." The A.I.Ch.E. is proud to add its congratulations to its representatives.

Membership Drive: We reported last month that Irv Leibson, who is captain of the Southern troops for the Membership Committee, sent his August report on red paper to indicate his embarrassment; his next report came out on green paper because he was "green with envy" at the number of memberships turned in by the Northern division under Sam West.

Cleveland Section has issued a history, directory, and constitution and by-laws. Dave Porter, who is chairman of the section, has also sent in a series of unique meeting notices prepared for the Cleveland Section . . . These notices are overprinted on a photographic or lined background; for instance, the announcement of a meeting on coal pipe lining was printed on a background map of the Cleveland area, and a talk on stocks was printed over the stock notices from the daily newspapers. According to Dave this technique was done by xerography. We hope that he will bring copies of these to the Sections Activities Meeting in Cincinnati for other Local Section representatives to see. If anyone can't wait that long, Dave can be reached at the Diamond Alkali Company Research Center at Painesville, Ohio.

Salt Lake City Meeting was an outstanding and pleasant one for all who attended . . . The hospitality and graciousness of our members there was a warm delight. On top of this the attendance went well beyond expectations, a tribute to their interest and activity, culminating in an excellent program both technical and social. Council met and reviewed many matters of importance, as is necessary in a growing and active professional group. One of the important items was a report by Council liaison members of committees. This year each Council member was assigned a sphere of operation and has made it a point to familiarize himself with all the activities of his group so that he may help in its decisions.

F.J.V.A.



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They are available with infinite modifications to respond to all modes of control in any type of instrumentation system for continuous process streams. They provide chemical feed control through manual or automatic motor speed or plunger stroke length adjustments. For more complex systems, each adjustment can respond to a different variable. For example, while speed varies from 0 to 100% with main line flow changes, stroke length adjusts from 0 to 100% to meet process pH requirements.

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Will you reap the long-term payoff
of good mixer shaft sealing?

If you want to minimize your mechanical fluid mixing costs, take a hard look at *mixer shaft sealing.*

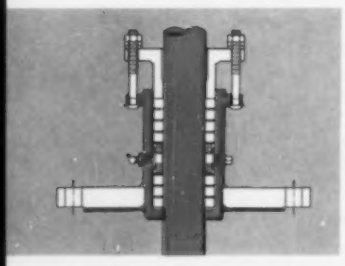
This is the area where profits can leak away unnoticed. The right shaft seal makes all the difference between an efficient mixing operation and a ruinously expensive one.

When you're aiming for low-cost shaft sealing, *don't be fooled* by low first cost. Instead, look for solid long-range savings you can make in terms of *smooth operation, rapid maintenance, minimum downtime.*

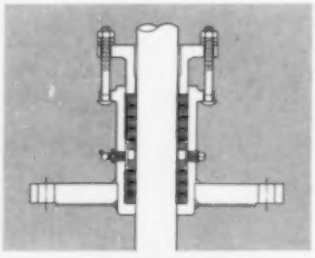
Here are some mechanical reasons why you get these savings with LIGHTNIN Mixers. Every one of the features illustrated below is a LIGHTNIN "first." Many are yours only with LIGHTNINs. And only LIGHTNINs give you *all* of them!

For lowest-cost fluid mixing, see your LIGHTNIN Mixer representative soon. Look him up in Chemical Engineering Catalog. Or write us direct.

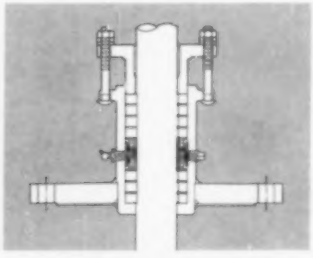
How you cut mixing cost with the *Lightnin* stuffing box



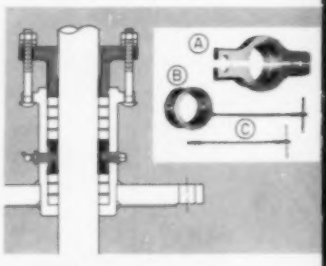
1. SAVE COST of a special-alloy mounting flange with all-welded LIGHTNIN construction. Forged steel flange is faced with correct alloy for your process conditions. Hub is solid alloy. Alloy parts are shown in color.



2. GET SUPERIOR SEALING with 7 rings of large-cross-section packing. Separators facilitate packing removal, distribute force uniformly. Gland bolts, threaded part way, prevent overtightening.



3. GET BETTER LUBRICATION without repacking. Lantern ring evenly distributes lubricant; permits continuous lubrication under pressure; extends time between repackings. Relief plug prevents overlubrication.

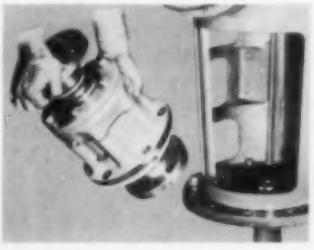


4. REPACK FASTER with exclusive split packing gland (A) that comes right off the shaft to allow maximum work space. Lantern ring (B) lifts out quickly by means of pullers (C), standard accessories.

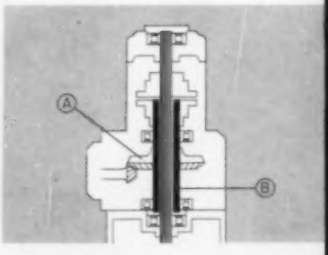
Get simplest possible maintenance with *Lightnin* mechanical seal*

1. ELIMINATE REPACKING and adjustment with this cartridge-type LIGHTNIN rotary mechanical seal assembly, optional on all LIGHTNIN Mixers. It's saving many users thousands of maintenance dollars a year.

2. GET WIDEST CHOICE of seal designs and materials to meet your conditions: stainless steels, Stellite, Hastelloy alloys, bronze, ceramic, Teflon, etc. Handle pressures to 2500 psig and all temperature ranges.



3. REPLACE SEAL ASSEMBLY quickly, if ever necessary—without dismantling mixer or removing it from tank, and *without skilled manpower.* Seal cartridge unbolts, comes out as a unit; replacement bolts in.



4. RETAIN GEAR ALIGNMENT when changing seal. Mixer gears (A) are isolated from shaft by hollow drive quill† (B) *—cannot get out of line* when seal is removed. Shaft realignment is automatic on reassembly.

†patented

WHAT MIXING OPERATIONS are important to you? You'll find a wealth of information on fluid mixing in these helpful bulletins describing LIGHTNIN Mixers:

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- ☐ Side entering: 1 to 25 HP (B-104)
- ☐ Laboratory and small-batch production types (B-112)
- ☐ Condensed catalog showing all types (B-109)
- ☐ Quick-change rotary mechanical seals for pressure and vacuum mixing (B-111)
- ☐ Confidential data sheet for figuring your mixer requirements (B-107)

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Lightnin® Mixers™

MIXCO fluid mixing specialists

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